

Review on Neuro – Managerial Decision Crescendos

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Abstract: *Manager has to take decisions with inadequate information. It is challenging to compare several courses of action and select one to be executed. Is building models of cognition or neurobiology an efficient means of answering managerial business decision questions? Qualitative research has been increasingly used in all disciplines. This thesis regards as 'psychological' any information that go beyond standard 'choice data'. 'Psychological' data and 'cognitive and neuromanagement' data have been interchangeably used. (Methodology is based upon deductive review approach. Attempts employ multi - method approach and triangulation of methods. It draws on positivist and interpretivist research paradigms. This likens methodology to building with 'foundation' (philosophical premises), 'pillars' (consisting of research approach / strategies / data collection / analysis matrix) and 'subsidiary inclusive structure' (operational framework). This starts from theoretic review leading to specificities. It is a waterfall - based ('top - down') approach. The review focuses principally on scientific literature concerning cognitive neuroscience research, business decision making process and economic experiments. When selecting studies for review, internet resources were searched with keywords: cognitive neuroscience techniques, business decision making process, business decision biases, intuition, cognitive load, experiment and economics. In the scope of neuroscientific research and experimental economics, contributions published in the past 15 years were preferred. In light of discussing theories and applications of neuromanagement science in business decision making, methods used in understanding brain patterns and neural activity viz. electroencephalograph, magnetic resonance imaging and magneto encephalography, computerized tomography, positron emission tomography, functional magnetic resonance imaging were reviewed.*

Key Words: *Managerial Decision, Neurodecision, neurophysiological techniques and cognitive management.*

Introduction

Thought - provoking problems concerning mind require collaboration of copious disciplines in intelligence sciences. In 1670, Blaise Pascal took first steps towards analytical understanding of decision - making. He argued that when one makes choices(s) he should weigh value of alternatives by comparing assessing worth of each of options. His work positioned foundation for social - scientific study of how humans decide. For three Centuries or so that followed, biologists generally avoided the topic. Physiologists of late 20th Century focused attention on brain systems attached to external environment (consists in exogenous set of alternatives and states) directly than cognitive systems associated with decision - making. In 1990 - 91, six academic papers used 'business decision' in their title and 'brain' in abstract. In 2016 - 17, that number jumped to 213. It seems that study of business decision - making is what we have learnt and what we might expect to learn in years to come (Glimcher; 2017). Synchronously, neuroresearchers made huge strides towards understanding where in brain subjective value is represented and towards understanding how it is constructed. Chastened by limitations of models from mid - twentieth Century, these researchers have begun to develop models that rely on additional variables in setting subjective value. This has given rise to 'emotional management'.

'Reverse combination' ('psychological management'), has been used as synonymous with emotional management. Emotional research is not always informed by psychology or interpreted in relation to it. Caution needs to be exercised. Some can be theoretical rather than driven by actual behaviour. Psychological management entails challenge to mainstream and other approaches that have sought to limit use made of ideas from psychology. It seeks to use inputs from psychology to obtain enhanced understanding of, and / or improved ability to predict, behaviour in respect of areas normally viewed as 'preserve of management'. Though it offers promise of greater functionality, this comes at a cost in terms of needing

to get to grips with unfamiliar notions, literatures and research tools. If researchers are not prepared to grasp this opportunity, they run the risk that psychologists will take it up instead and displace conventional management for business decision-making purposes (Earl; 2000).

Origin of business decision management is sketched to Smith's publication of 'The Wealth of Nations' (1776). Smith described phenomena that explain how environment influences behaviour, critical for appreciating business decision behaviour and aggregation of business decisions. Judgment and business decision-making research is no longer in its infancy with advancements in neurosciences over the last few decades. Diverse and varied, its origins can be observed directly in research conducted in 1950s and 60s. By 80s, field was sufficiently distinct and accomplished to support dedicated journals and edited collections. 1980s and 90s saw the field spread from its origins to other disciplines. Neuromanagement has potential to ineludibly change the way business decision-making is prepared. Following Aristotle and Thomas Aquinas, it is argued that business decision should consider 'integral rationality' to include 'instrumental' and 'practical' rationality. Practical wisdom helps business decision maker to determine how business decision contributes in each particular situation (Domènec; 2010).

One seminary of thought is that regularities in behaviour could ('*ceteris paribus*') provide psychological basis to manage (business decision) fluctuations. This led to investigate what structure of (managerial) business decisions might result from assumptions on preferences with normative flavour. Attention focused on idealised business decisions to describe how to choose. Weak Axiom of Revealed Preference (Paul Samuelson) proved assumptions about binary business decisions, revealing stable (weak) preferences with powerful inference. Optimal binary business decisions are determined by likelihood ratio, that is, relative probability of evidence given a hypothesis or another. When business decision-relevant information arises from multiple sources, evidence must be combined to make best decision. For binary choices, business decisions are optimised by sequential summation of log-likelihood ratio, expressing relative likelihood that information was drawn from one category or other. Subjective 'weight of evidence' for each sample depends linearly on weight assigned by manager. When some cues are more trustworthy than others are, best business decisions are made by adding up information weighted by its reliability (Summerfield; 2015).

'Generalised Axiom of Revealed Preference' posits that some (managerial) business decisions could design predictions about relative desirability of pairs of objects never directly compared. Turf originated in 70s when models began to merge with psychology to form emotional management. By end of 90s, limitations of neoclassical management dictated methodology that account for bio- psychosocial variables operative in non-rational business decisions. At present, neuro-managerial decision is considered a growing, experimental, pre-normative, descriptive and set of practices that engage neuroscientific approaches to assess and inform assumptions about managerial decision-making. In this, neurobusiness decision analyses contribute, compensate and are current plus future value in defining, guiding and perhaps predicting business decision activities. Thus, researchers must examine in which 'sense' and 'just how' precisely?

Few facets of human cognition are personal than business decisions made. Business decisions incessantly shape path of managers. It is a challenging task to compare several courses of action and select an action to be implemented. At times, task may prove too challenging through complexities in decision alternatives. Limited information-processing capacity of manager can be strained when considering consequences of only one course of action. Yet, choice requires that implications of courses of action be visualised and compared. In addition, unknown factors always intrude and seldom are outcomes known with certainty (Arsham; 2013). Primary goal has been to identify processes that underlie specific business decision variables, associated uncertainty and consequences of interactions. Recent work suggests potential neural substrates that integrate variables to assist comparisons. Choices do not merely identify one option among a set of possibilities. Choosing is an intervention (action) that changes the realm of decision making. As a result, good business decision generally requires specifying how actions are causally related to outcomes. Interventions license different inferences than observations because an event whose state has been determined by intervention is not diagnostic of normal causes of that event. Despite advances of business decision neuromanagement for elucidating brain mechanisms, significant challenges remain in understanding how brain produces phenomenal experience (Trends in Cognitive Sciences; 2006).

Business decision emotional change has come a long way. Researches have repetitively demonstrated that due to cognitive limitations managers act in a boundedly rational way. In recent years, they have developed fine-grained understanding of different behaviours in different contexts with

psychological processes behind. They have begun to think about how to consistently and transparently link understanding of behaviour to recommended interventions to change that behaviour. This outlines three interwoven lines of work that seem particularly pressing. These are;

- Linking linear behaviour change with understanding of complex systems,
- Developing basis for selecting behaviours to change, and
- Understanding 'behaviour' in first place.

Business decision - making emerges from complexly interlinked dynamics. How is information used in business decision - making and how can to study / understand its variation across managers and contexts? Investigations on business decision - making have been undertaken by different disciplines, each using different techniques and assumptions with few unifying efforts. Researchers focused on precise mathematical models. Psychologists examined business decisions based on cognitive constraints. Neuroresearchers concentrate on operation of neural systems in simple choices. In recent years, scholars have joined forces to better specify foundations of business decision - making. This interdisciplinary effort uses decision theory to search for neural bases of predictability. Concurrently, these models are beginning to incorporate processes yielding significant progress in construction of comprehensive business decision - making models (Sanfey; 2007).

Brain is a highly adaptive, self - organising complex system wherein neuronal responses and related behaviour are continuously optimised with respect to external and internal context. This is achieved by modulation of neuronal interactions depending on antiquity of previously processed information. Such meaningful connectivity changes, together with stochastic processes, influence ongoing neuronal dynamics. Role of such dependent fluctuations may be one fundamental computational properties of brain, being pervasively present in behaviour and leaving distinctive fingerprint in neuromanagement data. Combining advanced multimodal neuroimaging and computational modeling, researchers aim to identify generative mechanisms of neuronal dynamics and elucidate principles of interaction (Berlin School of Mind and Brain; 2017).

There is a need to explore how brain absorbs information, recognises / frames problematic situations and choose appropriate responses. These include building conceptual frameworks, integrating findings across disparate techniques / species

and extend results to shape business decision. Models have requirements that are not always applicable for research purposes. Specifically, models must be fabricated in reasonable amount of 'time'. Lucci (2013) proposes investigation of subjective component of time in intertemporal choice. Author asserts that deviations from exponential reward discounting, as function of time, could induce primary factor deviation of time. Time perception could modulate discounting which is a fundamental component of intertemporal choice.

Cognitive architectures help shorten 'time' to shape structure for representing tasks that form foundation for model - building activity. Cognitive architectures help address 'validity' (based on assumptions of empiricism). To overcome these, future research will likely focus on creating biologically plausible models (Smith and Huettel: 2010). Dawes (2001), Loewenstein (2005) and Mellers (2000) propose that next phase of research is likely to emerge from building on advances in neuromanagement. Shiv et.al. (2005) present a 'scrutiny' whose goal is to integrate research in how exponential accumulation of knowledge potentially enrich research on business decision - making, range of techniques that shed light on various business decision phenomena, specimens of potential research and challenges that need to be cognisant of.

Do humans (managers) make good business decisions? 'Human behaviour, in general ... is not under constant and detailed guidance of careful and accurate hedonic calculations, but is product of an unstable and irrational complex of reflex actions, impulses, instincts, habits, customs, fashion and hysteria'. (Viner; 1925). Emotional researchers continue to debate what might constitute a good business decision. Humans are particularly adept at modifying behaviour in accordance with changing demands. Through cognitive control, managers tailor actions to fit complex goals. In business, measurable techniques assist business decision - making. Biological systems are difficult to study. There is interest in exploring potential links between biology and management. This brings attention on mental processes in explaining managerial behaviour. What followed were series of proposals which extended scope of revealed - preference theory to (Managerial) business decisions with uncertain outcomes.

Auxiliary propositions exhibit a Manager who obeys 'as if' he has continuous utility function that relates subjective value of any gain to objective value. Moreover, 'as if' his actions aim at maximising total obtained utility. These form basis to

anticipate scrutiny unique to business decision management. What follow are models of mental processes and correlated intermediate variables (to predict business decisions from single neuron activity). Contributions characterise that business decision problems can be modeled through simple rationality model (maximise utility function of business decision Manager's business decision variables, a function which stanchly signify business decision Manager's preferences). Question is under what conditions such functions exist.

Managers perform pronounced quantity of work at inexorable pace. Neuromanagement explains how psychological processes are implemented; where and how psychological tasks are figured in brain. Cognitive task scrutiny generates comprehensive, precise information on nature of performance in a specific task. When implemented correctly, scrutiny techniques are valid sources of information on cognitive processes. This provides systematic procedures for ascertaining knowledge and answers traditional psychological questions. Neuromanagement 'sets the agenda' in that it specifies questions and provides framework to assess them. Neuromanagement can be extended and improved by reformulating psychological explanations. This has led to significant but 'controversial stand points'.

For a long time, scholars believed (and, generally considered) that managers take business decisions in a rational way. Moreover, it was possible to optimise performance considering different business decision moments. In this context, a School of thought opines; 'With emergence of neuromanagement and techniques of brain, study of behaviour has evidenced considerable bias about rationality, in particular, in times of managerial decision'. Drucker (1974) believes that many suffer from ineffective business decision - making because they do not understand the method. In a study, Mitroff, Emshoff, and Kilmann (1979) add that managers are plagued with pressures to act immediately and decisively. Consequently, committing 'time' to defining a 'business decision situation' and search information to make an effective business decision are unaffordable trappings. As a result, manager is required to take actions, which demonstrate whether it was the right or wrong solution. This has at its core the premise that Managers are under bounded rationality, and driven by cognitive biases unconsciously derived. This guarantees importance in development of management studies that represent reliable way for business decision - making and understanding complex management problems.

Janis and Mann's (1977) 'rational' model is useful to understand workings of 'classical' approach. Model assumes that business decision maker wants to achieve optimal outcome and emphasises need to act rationally through seven criteria to attain objective. Classical management perspective was the first well-developed framework for understanding management and consists of two distinct branches of scientific management and administrative management. Classical approach assumes that business decision maker has access to complete and reliable information concerning business decision being taken can process all information to define problem clearly and unambiguously. Further, it assumes business decision maker will be able to identify all possible solutions, is aware of consequences and evaluates by applying weightings to options. It is implied that business decision maker is not 'time' constrained in undertaking business decisions.

Do managers have complete 'ordering' of (manager) preferences in real - life cases? In examining business decision - making, Lisa Keenan and Jason Somerville (2016) find that traditional business decision methods fail to adequately explain aspects of business decision behaviour. As actual business decision - making does not fit rational paradigm originating from a spectrum of complete information, independent business decision - making and fixed preferences (Goffman; 1951, Schein; 1980, Luhmann; 1991 and Weber; 2005), variety of conceptualisations linking action to structure has emerged (Granovetter 1985; White; 1992). Davis (2014) argues that since utility function conception is derivative from 'standard rationality', interpretation that 'rationality' is 'bounded' suggests that distinctiveness should be comprehended as 'bounded'. Homo economicus utility function representation of Manager is conventionally understood.

Some theoretical and conceptual issues in business decision - making include, role of 'models' (Richard Gonzalez), contribution of neuromanagement, 'opportunities' and 'limitations' (Alan Sanfey), business decision from 'description' vs. business decisions from 'experience' (Ralph Hertwig), 'unconscious' processes (Emily Balcetis), 'meta cognition' (Asher Koriat) and models in 'reasoning' (Shane Frederick). Multiple facets include; business decision under 'risk' (Craig Fox), business decisions under 'ambiguity' (Stefan Trautmann), business decision under 'conflict': 'hedonic' vs. 'utilitarian' approaches (Ravi Dhar), 'time pressure', 'inter - temporal business decision' (Gal Zauberman), 'probability assessments', 'calibration' and 'overconfidence' (Don Moore). Methodological lines include; 'imprecise

sion' and 'noise' in business decision - making (Graham Loomes), 'experimental' practices (Andreas Ortmann), information 'sampling' and 'reasoning' biases (Klaus Fiedler) and 'joint' vs. 'separate' modes of 'evaluation' (Christopher Hsee). Contributions propose measurement techniques and paradigms that allow new insights into how models can be tested and / or compared.

In larger frame, challenges to standard view are challenges to Homo economicus utility function. In addition, there are problematic aspects of Homo economicus conception that create additional questions regarding standard view of rationality. The connotation is; individuality can be supposed to be 'bounded', with prospect theory (Kahneman and Tversky) and evolutionary thinking (Herbert Simon). A notable concept related to prospect theory and other descriptive models of choice and business decision - making is concept of reference - dependent preferences. How manager assesses outcome of choice is determined in large part by its contrast with 'reference point', as by intrinsic taste for outcome itself (Kahneman and Tversky, 1979; Koszegi and Rabin, 2006). Several authors proposed alternatives to Simon's phases (Glueck; 1976, Hofer, Schendel; 1978, Mazzolini; 1981, Schwenk; 1984, Gore, Murray, Richardson; 1992, Van de Ven; 1992 and Lu, Zhang, Ruan and Wu; 2007). Analysis of approaches show that each contribution consists of disaggregating or aggregating some phases identified in former contributions. However, three main phases proposed by Simon are present and existent models are in many respects similar (Fredrickson, 1985; Gore et al.; 1992 and Schwenk; 1984).

The above argument spectacles how different bounded managerial conceptions operate in nudge management and agent - based modeling explaining how they relate to emotional management of bounded rationality. Attempts to explain managerial behaviour, that appeal to rationality, share ontological assumptions and methodological practices that 'adaptationist model' in biology was criticised for. This, in biology, was largely abandoned as poorly motivated and replaced with active testing of adaptive and non - adaptive hypotheses regarding spread and maintenance of traits. This was welcome by biological community, despite having required development of new tools, conceptual or methodological assumptions and practices employed. Close attention reveal superficial similarities to critiques of 'adaptationism' in biology that extend to hypotheses regarding causes of managerial decision not embraced by the field as a whole. By attending to the ways, similar changes in business decision practice may be motivated (Kaplan; 2008). This is laconically reconnoitered in association with Kirman's Marseille 'scrutiny'. Author

extends bounded rationality to include individuality is bounded and interpret this to mean that Managers are limited in their capacity to act in a purely self - regulating way. This ontological investigation is precluded in coherent derivation of individuality.

Psychology and management have successfully demonstrated that behaviour is not endlessly variable, but can be captured and quantified by testable laws. Modern neuroscience techniques identify and link manager differences in business decision - making to differences in brain anatomy, brain responses, genetics and so on. Genetics is crude, but neuroscience goes directly to work on the brain, and the mind follows. In particular, neuroimaging techniques provide means by which brain responses can be monitored while subjects are engaged in economic - based emotional tasks (Human Neuroimaging Laboratory, Virginia; 2010). Over initial decade, managerial decision - making stimulated persuasive debates of two categories. One, whether it offers benefits. Two, which form managerial decision - making ought to acquire. Any iteration of management, as human endeavour, needs explanation of mechanisms and effects of emotional influence upon cognitive functions. Brain considers sources of information before business decision and prepares multiple accessible movements before deciding between them. Nonetheless, how does it do this? Why does process sometimes go awry, triggering impulsive, indecisive and confused business decisions? Neuro business decision - making offers tools for modeling behaviour (Satpathy; 2015).

The brain is never in wide-ranging peace. Even without external stimulation, spontaneous, self-generated brain activity can always be observed. In EEG, this spontaneous activity manifests itself as oscillations in different frequency bands. For a long time, researchers have already examined how extent of spontaneous oscillations at time of a stimulus presentation is related to perception of stimulus. Of particular interest are oscillations in alpha frequency band (8-12 Hz), which interfere with processing of visual stimuli. This interference can improve emotional performance in attention or memory tasks in which relevant information must be suppressed. In perception tasks, however, this interference leads to deteriorated performance. Despite numerous studies, understanding of this interference between spontaneous oscillations and stimulus processing is limited. This is because it is not understood which mechanisms this interference is based on.

Researchers investigate effect of neuronal oscillations using psychophysics and mathematical

modeling. A basic idea in modeling of cognitive and perceptual processes is that functional mechanisms ('amplification' or 'filtering') are theoretical constructs that cannot be directly observed in empirical data (hit rates or microvolt). Instead, they can be identified by modeling empirical data with models that mathematically explain relationship between functional mechanisms, experimental conditions and emotional data (Berlin School of Mind and Brain; 2017). With different disciplines approaching through characteristically different techniques and substantial advances (MRI, fMRI, BOLD, Positron Emission Tomography, Magneto encephalography, Near-infrared spectroscopy, Anatomical imaging, Invasive recordings, Lesion Studies, Transcranial magnetic stimulation, Transcranial direct current stimulation), question of how we design and craft judgments / business decisions has engaged scholars for decades (Satpathy; 2015). This review reviews neural bases of business decision parameters in management of business decisions.

Decision-making plays an important role in the transformation of incoming sensory information to purposeful actions. Many decisions have important biological and social consequences, while others may have a more limited impact on our everyday life. The neural mechanisms of decision-making currently constitute an important subject under intense investigation in the field of cognitive and emotional neuroscience. Among the investigations, on this topic, those involving sensory discrimination tasks using visual motion have provided a wealth of information about the nature of the neural circuitry required to perform perceptual decision-making. For example, by using a motion discrimination task, Shadlen and Newsome have shown an essential role of area LIP in perceptual decision-making. On the other hand, the importance of reward and reward expectations as determinants of decision-making is increasingly appreciated. In particular, reinforcement learning and economic theories, such as game theory, have provided valuable insights into the brain functions related to decision-making. By using a competitive game analogous to matching pennies against a computer, Lee's group showed that previous selections modulated prefrontal neural activity and that this modulation affected the current choice behaviour. The prefrontal cortex has been shown to participate in decision-making in free-choice conditions. By using a task involving the free choice of one target from multiple saccade targets, Funahashi's group examined the prefrontal participation in decision-making in a free-choice condition. They compared the activities of prefrontal neurons during an oculomotor delay task with forced-choice conditions and free-choice conditions and

identified the neural components reflecting the underlying decision-making processes. Although several attempts have been made to understand the neural mechanisms of decision-making, further investigations are required to fully understand these mechanisms. Future studies should evaluate the effects of emotions on decision-making and attempt to integrate the neurophysiological, psychological, and computational approaches to decision-making (Funahashi; 2008).

Neuromanagement offers solution through additional set of data obtained via series of measurements of brain activity at time of business decisions. Experimental neuromanagement can be construed as subset of experimental economics, where emotional data is enriched with brain data. Neuromanagement theory proposes to build brain-based models capable of predicting observed behaviour. Objective is to build models based on evidence from brain sciences. Measurement of brain activity provides information about underlying mechanisms used by brain during choice processes. In particular, it shows which brain regions are activated when business decision is made and how these regions interact with each other. This knowledge can then be used to build a model that represents this particular mechanism. Contrary to emotional economics, models does not rely on introspection or plausible assumptions but rather on existing and documented biological property of brain (Brocas and Carrillo; 2008).

Baptising brain as a hierarchical organisation (Brocas and Carrillo; 2008) opine that business decision sciences has experienced inflow of fresh ideas following the addition of elements from psychology into managerial decision models. Experiments in neuroscience provide invaluable information to business decision theorists about how to build better organisational models of brain. On the other hand, theoretical models of business decision-making processes can help experimental neuroresearchers determine which hypotheses about the architecture of brain deserve testing priority. Although it is far too early for an assessment, this methodology may eventually result in a new approach to managerial decision-making, moving from a single unit formulation with centralised business decision maker to a multiunit formulation with calculated interactions.

Brain has wide array of functions including functions to help interpret sensory inputs, originate and coordinate motor responses, control basic functions and retrieve information required to perform tasks, guide abstract and complex business decision-making. Brocas (2009) is of the view that models of business decision-making rely on sev-

eral important paradigms. First, managers' choices can be represented by well - defined utility functions (satisfying well - defined axioms). Second, managers are Bayesian processors of information. Even though these two paradigms have merits and account for proportion of observed behaviours still, anomalies have been reported. Most hypotheses formulated to justify anomalies are introspective and make implicit claims about underlying mechanisms leading to behaviour. In parallel, myriad of experiments try to describe brain processes involved in business decision. This evidence could and should shed light on fundamental causes of observed choice anomalies.

Brain uses specific mechanism to make business decisions. Neurons carry information from sensory circuitry, where information is received, to decision - making circuitry, aggregated and interpreted. Brocas and Carrillo (2008) have experimented that sensory system encodes information through cell firing. Cell firing is measured against a threshold and action is triggered depending on whether threshold is surpassed. Decision system modulates threshold. Authors show that optimal threshold is set in a way that existing beliefs are likely to be confirmed. They derive emotional implications. Neuronal thresholds and synaptic connections filter information. Depending on how high neuronal thresholds and / or how strong synaptic connections are, neuronal activity will be stopped or propagated along given path and trigger action. This mechanism is reasonable in that it requires minimal knowledge to reach a decision. Hanes and Schall (1996) used single cell recording to analyse neural processes responsible for duration and variability of reaction times. Mechanism can explain in a unified framework a number of 'anomalies'; (i) belief anchoring (order in which evidence is received affects beliefs and choices), (ii) polarisation (managers with opposite priors may polarise opinions after receiving identical evidence), (iii) payoff - dependence of beliefs and (iv) belief disagreement (managers with identical priors who receive same evidence may end up with different posterior beliefs).

How do managers perceive, think, feel, decide and act? How do they interact with their environments and others? How do these abilities develop and decline over lifespan? How do they evolve and compare with other species? How do they vary among managers, groups and cultures? How are they shaped by socio - economic and other factors? How are they affected by deprivation? What interventions can influence managerial behaviours or outcomes? Prediction is a pervasive requirement to be able to prepare for and adapt to complex, changing and challenging environments. Prediction is affected by cognitive and

computational factors including limited capacity attention, risk and uncertainty and affective biases. Literature provides rich body of computational theory addressing habit formation centering on temporal mechanisms. Less literature is observed in area of formalising processes involved in business decision - making. Authors draw on recent work in neuromanagement, cognitive psychology and developmental psychology to outline theory of business decision - making. Basic proposal is that, brain, within identifiable network of cortical and subcortical structures, implements probabilistic generative model of business decision - making stimulated through Bayesian transposal (Satpathy; 2015). Solway presents set of simulations implementing benchmark emotional and neuroscientific findings. This gives rise to set of testable predictions.

A number of studies have focused on how manager behaviour differs when choice set size (number of alternatives) is low vs. high. In some cases, large choice set sizes discourage managers from making a choice and in other cases, it either encourages them or has no effect. As increasing options are available, three problems emerge. First, is issue of gaining adequate information about choices in order to make decision. Second, having more choices leads to escalation of expectation. When there are increased options, choice 'spoils.' Third, with many options, one may come to believe they are to blame for unacceptable result because with so many choices, they should have been able to pick the best one. If there is one choice and it ends up being disappointing, world can be held accountable. When there are many options and choice that one makes is disappointing, manager is responsible. However, recent meta - analysis of literature on choice overload calls such studies into question (Scheibehenne, Greigeneder, and Todd; 2010).

Observation: At a glance, neuroscience and business may seem an odd juxtaposition. However, neuroscience of perception provides understanding of interrelatedness of subliminal credence patterns that drive behaviour and affect optimal business decisions. In the above context, how have psychology and management gotten along in past? Explanation rests on understanding of goals toward which management, viewed as a science has usually aimed. Recent eons have witnessed explorations between management and psychology. Managers are particularly adept at modifying their behaviour. Some behaviour patently fails to achieve goals in which they perform, leading often to downfall of managers and sometimes failure of entire organisation. Human complex systems are different from those in nature and cannot be modeled in same techniques because of 'unpredictability' and 'intel-

lect'. There is a need is to examine (and suggest) a solution.

Business decisions vary in terms of cognitive level and capacity to cope with complexity. They differ in terms of paradigmatic context. At extremes, some business decisions are decipherable within framework of assumption and emotional norms. Some require that assumption, behaviours and structures be conceptualised (or re-created). Immediate question is whether they include expansions that can be functional. Psychologists raise the converse question whether developments have implications for central staple of psychology. If management is able to find verifiable and substantiated generalisations about human (management) behaviour, then these have a place in general theories of human behaviour. Influences run both ways. Subjects tend to choose the highly rewarded alternative more frequently than called for by event matching. Hence, actual behaviour tends to be some kind of average between event matching and optimal behaviour (Simon; 1959).

Without engaging in reasoning and manipulation of information rationally, it is impossible for understanding and appreciation business decision dynamics. This review attempts to assess phenomena through manager action, business decision - making and reasoning processes. Objective is to put review models on neuro - management business decision, in which interaction between variables of neuro - management business decision progressions are addressed. Attempt is to describe a hybrid model with intent of linking neuro and management levels of scrutiny capable of predicting observed behaviour (Satpathy; 2015).

Focal point in this review is to review model of neuro - managerial decision and understand;

- Neural processes underlying how managers craft business decisions.
- Understand mechanisms of business decision - making using neuroimaging methodologies.
- Integrating transdisciplinary research to business decision management.

Brain Tectonics

It has been said that man is a rational animal.
All my life I have been searching for evidence
that could support this.
..... Bertrand Russell

Neuro - business decision, result in selection of path of action among alternative circumstances. Managers' resources rely on cautious simulated neuro - models to display relationship between

'cause' and 'neuro incongruity'. Business decision via introspection leads to model selection problem is viewed as integrated incessant process concerned with rationale, reasonableness and invariant techniques. Managers perform cognitive tasks. Problem in descriptive and prescriptive research in business decision - making is to identify 'regions of rationality,' i.e., areas for which heuristics debatable. This offer information concerning brain activity during diverse cognitive processes but not about underlying relationship linking brain expanse and cognitive functions.

Specific brain structures potentiate business decision - making depending on strategy, traits and framework. These reflect compensatory interface of neuromanagement decision related expanse. Trait approach propositions stable psychological characteristics possessed by managers. Enduring attributes lead managers to decide. Hornaday (1982) has identified 42 attributes possessed by managers. Among those, risk taking propensity (Brockhaus and Horowitz; 1986), need for achievement (McClelland; 1961), tolerance for ambiguity (Begley and Boyd; 1987) and internal locus of control (Brockhaus; 1982) are recurrently cited. Question is whether a rational move happens always to be a right move. This leads to creation of 'business decision - paradox'.

Conjecture of brain is aptitude to trait mental states; attitude, intents, requirements, pretends comprehension, etc. to oneself and others to appreciate those others have dissimilar beliefs, desires, intentions and stand points. This is a supposition insofar as brain is not directly evident. Supposition that others have brain is termed a conjecture, as each human can barely perceive subsistence of his own brain through introspection. None has unswerving admittance to brain of another. It is characteristically implicit that others have brains by parallel with one's own. This assumption is based on shared nature of interface, efficacies and perceptive of others sentiment and dealings. Managerial efficacy is cognitive capacity necessary to manage judgment, sentiment and procedures. It refers to high - level cognitive skill to manage / direct cognitive ability and behaviours.

A study (Satpathy; 2015) was designed to help understand what effective managers really do, examine personage difference in conjecture of (psyche) and managerial functions to explain variation in severity of efficacy symptoms that account for inconsistency in behaviours symptoms. This model consists of continuum ranging from quantity - oriented manager (observed to display significant activities / performance) to quality - oriented traditional manager (observed to exhibit interface with

outsiders, controlling / planning activities and perceived to have quality performance). This model helps identify needed managerial activities / skills for business decision - making. These findings are discussed in terms of distinction between aspects of model of mind and related managerial control.

Existing deliberations have ancestry in rational debate that set basis for making allowance for discipline of brain dynamics (Satpathy; 2015). Having conjecture of brain allows to element judgment, requirements and intention, forecast / elucidates actions and hypothesise intentions. Initially distinct, it enables to explicate and calculate behaviour of others. Being able to feature mental states and perceive them as cause of behaviour implies brain as an author of representation. If manager does not have conjecture of brain, it may be a symptom of cognitive or developmental mutilation. Managerial efficacy (cognitive influence and managerial - attention organism) is umbrella term for management (regulation, power) of cognitive processes (Satpathy; 2015). Managerial scheme is theorised cognitive configuration that directs cognitive processes. Conventionally, managerial efficacy has been synchronised by prefrontal regions of frontal lobes. Prefrontal areas of frontal lobe are necessary but not solely sufficient for hauling out this efficacy. Nevertheless, it is a matter of unending contest. Frontal and non - frontal regions are essential for integral efficacy. Managerial system is ideated to be drawn in handling situations exterior domain of mechanical processes. This explains imitation of set behaviours; those that engross scheduling or decision - making, those that involve inaccuracy rectification and those that necessitate overcoming of tough response (Satpathy; 2015).

Neuro - managerial decision research has reliably identified brain network representing manager preferences and business decisions. Over the last decade, brain network has been delineated using neuroimaging methods (Padoa - Schioppa and Assad; 2006, Schultz; 2006, Kable and Glimcher; 2009, Grabenhorst and Rolls; 2011, Padoa - Schioppa; 2011, Rushworth et al.; 2011, Lee et al.; 2012, Levy and Glimcher; 2012, Platt and Glimcher; 1999; Tremblay and Schultz; 1999). In a neuroimaging experiment, participants view different stimuli and choose an option to derive a measure. This is used as a parametric regressor to identify brain regions that show systematic activation changes. Number of converging studies identify network of brain areas representing stimuli (Kawabata and Zeki; 2004, O'Doherty; 2004, Kim; 2011; Levy and Glimcher; 2012). Consensus suggests that brain assigns value to each option and

compares to make a business decision. Smaldino and Richerson (2012) argue that current paradigms in neuroscience are focused on business decisions made among a previously established set of options, although, generation of options has barely been studied and still largely an untapped issue. The authors consider various specific factors that could influence generation of options. Question is whether brain computes these business decisions by comparing values of stimuli directly or by first assigning values to associated actions and then a business decision over actions (Wunderlich; 2010). Research has neglected questions as why Managers choose what they choose, or why different Managers choose different things. At proximal level, this is addressed by manager reinforcement histories (Lee et al.; 2012). Research on distal motivational principles that predict business decisions across situations is needed.

Does 'recognition' play role when it comes to inferences and choices? Studies investigate how managers make decisions based on previous encounters with object or situation. This review propositions an introductory overview of neuro - managerial decision. This is a new, multi and trans - disciplinary orientation to managerial thinking that interweaves renewal of managerial managements, in particular 'new experimentalism'. Pitch integrates trans - traditional and managerial anthropology. It reveals potential to become an important pillar oriented toward multi - dimensionality, integration of scientific insights, sustainability and realistic humanism. In recognition of bio - managerial realities, attempt includes anthropological, situational and socio - cultural dimensions to assume appropriately multi - dimensionality and inter - disciplinarily to experimentally broaden limits of 'classical' and 'pure' business decision thinking.

How manager make business decisions in their brain? Psychological models explain that humans gradually accumulate evidence for a particular business decision over time and execute when evidence reaches critical level. Brain considers sources of information and often embodies conflicting values. Manager often fail to design 'rational' business decisions. When faced with obscure business decision, they engage in simplifications of business decision problems. How do parts of brain that govern business decision - making coordinate activity of business decision? This review explores certain neuro-underpinnings in managerial decision modeling.

In neuromanagement, how brain processes different sensory stimuli and which are the neural basis involved have been studied in past decades.

Impairments in business decision - making are at core of psychological and neurological impairments. Model of brain function explain range of anatomical and physiological aspects of brain schemes. Brain accumulates evidence when faced with an assessment and triggers an action once evidence reaches tipping point. However, how do managers know where they are, where they have been and where they are going? It is important to understand intricacy of managerial brain. Neuro-physiological models aim to explain mechanisms by which business decisions are generated. These models seek to explain behaviour, causes and employ constraints at algorithmic level to validate plausibility of predictions. One might address these models as 'because' models.

Important open problem in business decision management is: what value signals are used in guiding different types of business decisions, where are they stored in brain and how does brain compare them to make a business decision. An emerging theme is that organisms need to make number of value-related computations to make simple business decisions. Consider action - based business decision exemplified by manager. First, he needs to assign value to each action under consideration. These 'action values', encode value of each action. Second, these action values are compared to generate a business decision. Third, value of option that is selected (chosen value) is tracked to reinforce learning. By comparing value of outcome generated by business decision to chosen value, organism can compute prediction - error signal to update action value of chosen option. While action values are computed before business decision is made, chosen value and outcome of comparator process signals are computed afterward.

Rational Business Decision: What is rational business decision? Cognitive business decision theory is a scientific analysis in which something complicated is (formally) presumed. Green and Shapiro (1993) treat it as empirically worthless but nonetheless highly pretentious theory. Shepsle (1995) treats it as worst social scientific paradigm managers we have, except for all the rest. In addition, scholars have elsewhere (Cox; 1999) reduced it to game theory, called it a methodology and analogised it to statistics. This review considers rational business decision as a paradigm, hard-core methodology, reducing it to neuromanagement decision metrics.

Methodology consists in building models to demonstrate relationship between cause (preference for particular object) and emotional anomaly. There are two fundamental comparative value

concepts, 'better' ('strict preference') and 'equal in value to' ('indifference') (Hallden; 1957). This formulates possible explanations for emotional data. This qualitative picture is 'translated' into measurable scientific framework, which usually involves expressing hypothesised relationships as ordinary or partial differential equations or related objects, such as difference equations, as state variables that evolve in space and / or time. model, once constructed, is still nothing more than a guess and testing it with goal of building circumstantial support for it (or against it) is then carried out by numerical simulations of processes being modeled, often where answers or outputs are known from experiment and can be compared with outputs computed by model.

Above methodology, have two advantages. Evidence from brain management provides precise guidelines for constraints that should be imposed on business decision processes. This helps uncover 'true' motivations for 'wrong' business decisions and improves predictive power. Emotional theories build on specific models of preferences. Rather than guessing a cause for biases, theory builds model based on existing physiological properties underlying belief formation. In principle, these help pinpoint biological foundations for anomalous business decisions. Research demonstrates that brain cannot encode all information contained in a signal. Business decision is triggered when 'enough' information supporting one alternative is obtained and uses biological mechanisms to filter information in constrained optimal mode (Brocas; 2009).

Key aim of this review is to relate construct of cognitive style to existing models in neuro - managerial decision. This is to outline a framework that integrates findings on manager differences across different disciplines. First, review portrays cognitive style as patterns of adaptation that ripen based on innate predispositions / interactions shaped by changing demands. Second, research in business decision - making addresses the same phenomena. Third, review of research support validity of cognitive style. Fourth, various styles from disparate disciplines can be organised into a single 'taxonomy'. This allows integrating cognitive and business decision - making styles to adaptive systems.

Historically, 'cognitive style' refers to consistencies in manager's manner of cognitive functioning, particularly in acquiring and processing information (Ausburn; 1978). Messick (1976) defines cognitive styles as stable attitudes, preferences or habitual strategies that determine managers' modes of problem solving. Witkin, Moore, Goodenough and Cox (1977) characterise cogni-

tive styles as manager differences in ways Managers perceive, think, solve problems, learn and relate. Although it seems obvious that there are differences in how Managers habitually process information, it is not obvious how best to characterise such differences (or determine significance). Despite being popular throughout 1950s to 1970s, research on cognitive styles has been questioned. Currently, research has reached a standstill and doubt whether concept of cognitive style has utility. In fact, many use concepts such as 'perceptual affordances,' 'dispositions,' 'patterns of learning' and 'learning orientations' to conceptualise differences associated with 'cognitive style' (Friedrich).

Turpin (2004) compares number of theoretical models in which managers make business decisions. Significant variation was found in personal business decision - making styles. Study attempted to provide business decision support consultant with insight into decision - making style of manager. Only when such business decision - making is understood can one claim to truly support it. In operations research, scientific method is used to focus on rational components in solving problems to managerial decision - making. Methodological base for issues have been dealt with by Argyris and Schön (1978), Hahn, Doh and Bunyaratavej; 2009, Vendelø; 2009, Easterby - Smith; 2009, Cha, Pingry and Thatcher; 2008, Hult, et al.; 2000, Barrados and Mayne; 1999, Daft and Huber; 1987, Dekker and Hansen; 2004, Dery; 1983, Fry and Griswold; 2003, Garvin; 1993, Huber; 1991, Levit and March; 1988, West; 1994 and Fiol and Lyles; 1985).

Despite rapid decline in research on cognitive styles by end of 1970s, in applied fields (business and management) publications continued to increase dramatically, reflecting high practical value of construct in applied settings. Working in isolation, scholars did not develop terminologies that had either clear definitions or it clear how they differed from traditional characterisations. Furthermore, some made frequent reference to, and focused on, naïve or outdated assumptions about how brain processes information (popular narrative about left -brain vs. right brain differences) or confounded and combined cognitive style with psychological constructs. These produced 'chaos' and led to greater skepticism about utility of rational style. Reviewers (Curry; 1990; Evans and Cools; 2011; KoganandSaarni; 1990, Kozhevnikov; 2007, Rayner and Cools; 2011, Sternberg and Grigourenko; 1997, Zhang, Sternberg, and Rayner; 2012) noted that concept of cognitive style fell short due to lack of framework that united and systematised proposed style dimensions. In response, advocates of construct cognitive style

proposed variety of unifying frameworks (Allinson and Hayes; 1996, Curry; 1983 and Riding; 1991 and Sternberg and Grigourenko; 1997). Although some of these are sophisticated, none of these constructs with contemporary neuromanagement theories of business decision processing. Thus, basic-management could not offer applied fields a coherent framework to organise and understand manager differences in cognition to which cognitive style could have been mapped.

Systematic neuromanagement research gained traction in 1990s (Kosslyn; 1996). Most work focused on speed of processing, working memory capability and runny intelligence. For more than a Century Managers have used theoretical assumptions to argue that general intelligence constrains business decision - making quality, causing substantial differences in managers' potential and outcomes. Although variations could lead to cope with specific situational challenges, on manager differences does not have this focus. Research focuses on variations in functioning of specific aspects of information per se. In contrast, scholars consistently used cognitive style to describe manager differences in cognition that help managers adapt to circumstances. Particular style represents particular situational sensitive differences that arise from system of interacting processes, not a single process working in isolation (Klein; 1951 and Witkin et.al.; 1962).

In short, research suggests that some styles might operate at superordinate metacognitive level. Such metastyles determine flexibility with which Manager chooses most appropriate subordinate style for a particular situation. More generally, research suggests that it is useful to organise styles hierarchically. Managers in hierarchic mode do not rush to judgment. Instead, they analyse information and expect others to contribute and will readily challenge others' views, analyses, and business decisions. From hierarchic standpoint, business decisions should stand test of time. However, this only raises the question of what consumes the time. For business decisions informed by sequence of samples of evidence, answer is straightforward; more samples are available with more time. Speed and accuracy of such business decisions are explained by accumulation of evidence to a 'threshold' or 'bound'. However, the same framework seems to apply to business decisions that are not obviously informed by sequences of evidence samples. Computational cognitive theories called 'evidence accumulation models' have explained speed accuracy tradeoff as changes in amount of evidence necessary to trigger selection of response. Studies speculate on neural mechanisms that link sampling of evidence from

memory to circuits that represent accumulated evidence bearing on a business decision (Shalden; 2016).

Managerial Cognitive Requirements

Managerial activity, in terms of neuromanagement, is concerned with extreme behaviours. This is concerned in mapping out neurophysiological and cognitive mechanisms across spectrum of managerial behaviours encountered. It proposes that competing neuro - emotional business decisions systems hypothesis (Bickel, et al.; 2012) captures range of managerial behaviours that can be characterised as 'hyper' or 'hypo' - activity in either limbically - based impulsive system or frontal - cortically based managerial system with corresponding level of activity encountered in alternative brain region. This pattern features in Somatic Marker Hypothesis (Damasio; 1994) and Reinforcement Sensitivity Theory (Gray and McNaughton; 2000 and McNaughton and Corr; 2004). In discussing these, there is a need to review role of cognitive explanation in neuro - emotional business decision, neuro - managerial decision micromanagement (Ainslie; 1992) and suggest solutions to problems of imbalanced neurophysiological activity in managerial behaviour. By considering adaptive - innovative cognitive styles (Kirton; 2003), a theme can be reviewed through psychometric scrutiny involved in managerial decision - making and underlying neurophysiological foundations.

Cognitive explanation provides understanding in which managers subjectively respond to circumstances, which influence behaviour towards short - term and long - term consequences. Being able to characterise what manager's desire and believe in these situations, what they perceive and how they feel, provides indication of underlying disposition to respond in a particular way at different times. This is a highly theoretical enterprise. In order to avoid undue speculation and conjecture, it is important that coherent body of knowledge provide cognitive requirements of neuro - emotional business decision. Required exposition must indicate particular intentional terms applicable to explanation of behaviours within framework of overall theory that can relate behaviour patterns. It must be capable of explaining how intentional entities act upon impulsion substance, in order to bring about advantageous long - term result. This calls for a 'theory of behaviour' over continuum of normal to addictive behaviours rather than an ad hoc application rapid observation of behaviour.

Managers make business decisions in complex situations. Neurobusiness decision - making pre-

requisites Manager to be responsible for business decisions. Manager has number of alternatives and must choose the best alternative (or, an optimised combination). When this has been made, events may have occurred (maker has no control). Each (combination) of alternatives, followed by an event, leads to a result with some quantifiable significance. Cognitive management suggests that diverse preference orderings and business decisions possibly will surface depending on which brain circuits are activated. This perchance contradicts micromanagement postulate that one complete preference ordering provides sufficient information to predict business decision and behaviour.

Nobel Laureate Amartya Sen, in an interview at Harvard University (date / year not mentioned), argues that emergence of complete preference ordering may be prevented by existence of conflicting motivations. Sen criticises existence of competing motivations (or 'reasons for business decision') stating that unique preference ordering is not sufficient for describing behaviour (unless, by chance, all motivations provide same preference ordering). Nonetheless, author does not provide explanation of how different motivations impact on business decision explanation. Not all brain circuits are activated when executing response to given circumstances. A key insight is modularity of human brain. Same stimuli may generate different emotional responses depending on which brain circuits are activated. If proposition is precise, different brain circuits guide different business decisions depending on which brain structures and circuits are activated. Consequently, there would be various (possibly conflicting) preference orderings. Furthermore, if a particular brain circuit could act relatively insulated, distinctive preference ordering would result (closed system).

Premise of neurobusiness decision theory is existence of multiple interacting brain systems. Relationship between brain systems is intricate. Typically, each system performs different functions and each function needs intervention of several systems. Neuroresearchers refer to it as brain modularity. Taking a business decision, solving a problem or performing a motor task requires coordination of different functions and consequently involvement of different systems. Depending on nature of function and degree of overlap between systems, they produce response that is 'as if' they were cooperating with each other or 'as if' they were competing with each other. Brain modularity is a key concept in neuroscience. It challenges common view of single coherent self-adopted. Multi-process theories of business decision-making rely on existence of several brain systems interact-

ing with each other to revisit standard paradigms of choice, propose choices that fit emotional data better and offer testable predictions.

Preferences are inherently subjective and arise from mixture of aspirations, thoughts, motives, emotions, beliefs, and desires. This inherent subjectivity means that preferences are not easily evaluated against objective criteria without knowledge of manager's goals. Most studies define rationality in terms of consistency principles. These principles place 'bounds' on rationality, bounds that range from perfect consistency to weak stochastic transitivity. Researches on preferential business decision demonstrate how and when managers violate these bounds. Many of these are interconnected and reflect systematic emotional principles. Rieskamp (2006) discusses violations and reviews theories that predict these. Author examines how, when and why managers violate consistency principles that embody traditional view of rationality. Five constraints are addressed that are moderately ordered on a continuum from strictest to weakest.

Consistency properties are internal to neuromanagement decision function. Samuelson's 'revealed preference' formulation is scientifically respectable (since) if manager's behaviour is consistent, then it must be possible to explain behaviour without reference to anything other than behaviour. Sen (2002) identifies 'internal consistency' approach and 'self - interest pursuit' approach, respectively. Internal consistency model explains behaviour by finding regularities in observed behaviour that enable to assess consistency without reference to anything other than (or external to) observed behaviour. In order to predict neuromanagement decisions, scholars work out which preferences are consistent by checking whether 'agents' do or do not violate certain axioms of revealed preference. Rational agents display rationality by making business decisions. Some are basic while others concern more on crucial issues.

As we investigate neuro - managerial agent, many levels of philosophical issues come to the fore: ontological, epistemological, methodological, psychological, ethical. Since neuro - managerial philosophy must reflect on theory and practice of neurobusiness decision management, articulation and clarification of practical consequences in terms of choice, justice, welfare is needed to depict and represent economic agent satisfyingly (3rd International Conference Economic Philosophy, France; 2016). The complex network of all these issues is at core to bring clarity about what is at stake in understanding of the neuro - managerial agent and its representations. Possible topics include; 'indi-

viduality' of neuro - managerial agent and her rational behaviour, ontology and epistemology of neuro - managerial agent preferences, normative and positive models of the neuro - managerial agent and neuro - managerial agent and its identity.

Supplementary approach is 'self - interest pursuit' approach. It is presumed that self - interest, represented by complete preference ordering, dominates motivations in coherent matrix. 'Rational' behaviour consists in pursuit of self - interest. This provides basis for application of utility theory in coherent scrutiny that represents managers' preferences and explains how preferences determine (neuromanagement) business decisions. Internal consistency is neither sufficient nor necessary condition. It is not sufficient because '[a] manager who chooses things he values least and hates most would have great consistency of behaviour, but he can scarcely count as a model of rationality.

There may be actions that are rational but where axiomatic conditions of consistency of behaviour would not obtain. Internal ('intrinsic') psychological structure of Manager may be affected by conflicting motivations, values or goals, each corresponding to different ordering and interacting in a mode that precludes emergence of internally consistent preference ordering. External (extrinsic) factors may influence (neuromanagement) decision based on 'menu - dependence'. Changes may modify attitude towards other elements thereby changing preference ordering. These contravene axiomatic conditions of internal consistency that require orderings to be independent from external conditions.

Emotional experiences can subconsciously influence business decision-making efficacy and efficiency. The idea is radical, and for the longest time in psychology, was scoffed at with utter disregard. Emotions certainly trigger bodily reactions in response to both internal and external stimulation, but for greater part of human history, mind and body were thought to be separate. Thoughts and bodily experiences could not be presumed to fall within same spectrum of physiological relevance. Distinct, orthogonal, and without any potential for overlap, mind and body (Dualism) can connect but were anything but unified. Decades have passed since age of Descartes' classic perspective, and yet science remains timid to explore physical possibility of emotions within brain (Reynolds; 2014). Survey of interactions between cognition and emotion in managerial decision - making lead to the following;

- What are the reciprocal relationships between cognitive and affective processes?

- What are the neurobiological underpinnings of above interactions?
- How does emotional valence of information affect?
- How do emotional factors influence judgments and preference?
- How do relationships between cognitive and emotional influences on business decision?
- To what degree can these be explained in underlying neurobiological systems?
- What neuroemotional and computational capture interactions of cognition and emotion?

Survey of interactions between manager differences in managerial decision - making lead to the following;

- What psycho - neurobiological processes distinguish expert business decision - making?
- How do managerial differences affect business decision - making?
- How do motivational state and goal orientation influence business decision - making?
- What neurobiological systems support different motivational states?
- How does proficiency affect business decision - making?
- Are low proficient managers more likely to use intuitive rather than analytical processing?
- How consistent are discount rates for inter-temporal business decision?
- What are the pathways by which business decision processes are influenced by biology?
- How do situational factors direct development of business decision - making capacities?
- How does business decision - making influence neural processes?

To what extent do managers know minds when making business decisions? Variants of this question have preoccupied scholars in a wide range of domains; experimental psychology (cognition, perception, social behaviour) to cognitive neuromanagement and emotional management. A pervasive view places heavy explanatory burden on intelligent cognitive unconscious, with theories assigning causally effective roles to unconscious influences. This review identifies a framework for evaluating these claims and evidence from three major bodies in which unconscious factors have been studied: multiple - cue judgment, deliberation without attention and business decisions under uncertainty. Tendencies to rely on deliberation and intuition are often construed as orthogonal dimensions (Hodgkinson and Sadler-Smith; 2003). Consequently, manager's business decision style does not represent preference of intuition over delibera-

tion, but expresses strength of tendency to rely on respective business decision mode.

Volatility, Uncertainty, Complexity and Ambiguity (VUCA)

Managers are moving from world of problems, to world of dilemmas. In good old days, managers could research an issue, deliberate on pros and cons before reaching sound business decision. Those business decisions became precedents, clearly defining a path and eliminating guesswork. Pace of change was measured, controlled with reference to capacity and capabilities. One problem is that for many centuries, managers have been raised in a context in which managers believe the world is predictable. Managers now need to work with a different mind - set, where important thing is not to focus on what is 'probable', but what is 'possible'. This is a world where volatility and uncertainty have become 'new normal'. Managers look at the World through a lens, 'VUCA', which stands for 'Volatile, Unstable (Unbalanced, Uncertain, Unsecured, Unreliable), Complex ('chaos', Confusion, Compound, Composite, Convolved) and Ambiguous (Ambivalent).'

VUCA, in Wikipedia describes or reflects on ischemic failures and emotional failures, imperative to (managerial decision) failure, At some level, capacity for VUCA management hinges on enterprise value schemes, assumptions and natural goals, A 'prepared and resolved' enterprise is engaged with strategic agenda that is aware of and empowered by VUCA forces. The under listed elements present a context in which managers view their current and future state. These present boundaries for business decision. Working with deeper smarts about elements of VUCA may be a driver for survival and sustainability in an otherwise complicated World,

- V (= Volatility): Brutal increase in dimensions of type, speed, volume and scale that represent dynamics of change forces and catalysts.
- U (= Uncertainty): Lack of predictability, prospects for surprise and sense of awareness and understanding of issues and events.
- C (= Complexity): Multiplex of forces, confounding of issues and disorder / confusion that surround a manager.
- A (= Ambiguity): Haziness of reality, potential for misreads and mixed meanings of conditions; causes and effect confusion.

VUCA pervades managerial decision. Nearly all real - world business decisions involve some form of psychological uncertainty, whether about likelihood of an event or about nature of future preferences. Most studies have examined effects of risk (Knutson and Bossaerts; 2007, Platt and Huettel; 2008, Rushworth and Behrens; 2008). While definitions vary, a 'risky business decision - making' involves potential outcomes that are 'known but probabilistic' wherein, risk increases with variance among outcomes, potentially normalised by expected value (Weber; 2004). Consequently, risk - taking appears to be a distinctive feature possessed by managers (Das and Teng; 1997). Leibenstein (1968) argued that manager is 'ultimate uncertainty and / or risk bearer'. Gasse (1982) contends that risk - taking propensity fundamentally distinguishes managers. Some empirical studies (Hull, et al.; 1980) reported that managers were risk - taking when starting a business. Koh (1996) found that managers with managerial inclination had higher tendency to take risk than those with no managerial inclination. Bowman (1969) has developed a theory which claims that manager makes good business decisions on the average but that he may exhibit high variance in his behaviour.

When manager has limited information, a plan based on average behaviour performs considerably better than actual initial plans. However, when situational cues provide reliable information as when revisions are made. Then actual business decisions are clearly superior to those suggested by an average rule. This review proposes three general criteria that must be satisfied. These tests are used to evaluate a production planning model where rules are based on 'average' past behaviour. Several interesting results emerge when comparing production plans based on 'average' rule with actual plans. This offers insight into potential usefulness as well as limitations of Bowman's hypothesis. Suggestions for future research in this general area conclude the discussion.

Only a handful of studies have investigated neural basis of ambiguity (Smith et al.; 2002, Hsu, et al.; 2005, Huettel et al.; 2006 and Bach et al.; 2009). Tolerance for ambiguity is willingness to act in uncertain situation (Bhide; 2000). VUCA can have other forms (Ellsberg; 1961). Probability enters by playing role of substitute for certainty. This is substitute for complete knowledge. Probabilistic models have been used for protection against adverse uncertainty and exploitation of propitious uncertainty. Moreover, still other states of uncertainty might be evoked in cases where outcomes themselves are unknown. So far, research has established weak, albeit numerous, links

between uncertainty and neural substrates. It is argued that managers are willing to tolerate ambiguity because activities they perform are often uncertain. They 'eagerly undertake 'unknown' and 'willingly seek out to manage uncertainty' (Mitton; 1989). Many do not want to pursue potential opportunity because of innate or psychological unwillingness to act in face of uncertainty (Bhide; 2000). Koh (1996) found that managers who were managerially inclined had more tolerance for ambiguity than those who were not. Tolerance for ambiguity is important, but factors such as skills and backgrounds help managers venture into uncertain world (Bhide; 2000).

During managerial decision - making, risk modulates regions of lateral prefrontal cortex, parietal cortex and anterior insular cortex (Mohr et al.; 2010) in brain. This contributes to adaptive control aspects of behaviour. Yet, risk influences activation in other regions seemingly associated with simpler sensory, motor or attentional processes (McCoy and Platt; 2005, Berns. et al.; 2001 and Fiorillo et al.; 2003). Presence of ambiguity likewise modulates activation support managerial control (Huettel et al.; 2006) and regions that track aversive outcomes (Hsu et al.; 2005). In some studies, brain regions have been interrelated to characteristics of managerial decision - making problem, business decisions made and manager differences in uncertainty aversion. Still needed are characterisations of both common and distinct computational demands associated with different sorts of uncertainty, which would in turn provide new insights into neural function.

'Chaos' in Managerial Decision

'Principle of Unificity' (Griçfiths; 2003) concerns quantum concept of 'entanglement'. There are strong empirical reasons for calling into question classic probability theory as adequate explanation for human judgment and business decision behaviour. Quantum theory provides account that unifies all diverse findings within common theoretical framework. Finally, quantum theory introduces important new concepts, including superposition, compatibility and entanglement, to help explain human cognition. Busemeyer (2004) examines six theoretical reasons for considering application of 'quantum theory' to human cognition. Almost all previous modeling has relied on principles derived from classical probability theory. Nevertheless, these fields have encountered puzzling. Findings that seem impossible to understand within this limited framework. Quantum principles may provide some solutions. The first reason concerns the quantum concept of superposition. Second reason concerns sensitivity to measurement of the

cognitive system. Third reason concerns the quantum concept of measurement incompatibility. Fourth reason is that human judgments do not always obey classic laws of logic and probability. Fifth reason concerns assumption of classic probability models.

Brain is a macroscopic physical system operating on scales that differ from corresponding quantum scales. In microscopic world of quantum mechanics, uncertain principles make universe non-deterministic. Quantum probability provides way to explain human probability judgment errors including conjunction and disjunction errors. Quantum cognition community states that activity of neural networks produce effects formally described as interference (of probabilities) and entanglement. In addition, due to 'chaos' in managerial decision-making, similar things does appear in macroscopic world of daily life. Due to 'chaos' in managerial decision making, small causes may evolve in time that could pose tremendous effects. This review discusses possible causes of 'chaos' in managerial decision-making. In business decision-making logic, there are rules how and when 'chaos' in business decision-making is easy to pronounce. Present review gives hints where logical considerations of 'chaos' in managerial decision-making become vital. Which system shows 'chaos' in decision making and which does not is a central question? There is no realistic chance that it will be averaged out. How to handle chaotic systems? There is no customary approach to deal with 'chaos' in managerial decision making.

Neuro - Decision 'Traps': Managers often make a 'less than optimum decision' because of ways human brain is wired. It is possible to imag-

ine where understanding, appreciation and reasoning are intact, but manager has no way to communicate intended decision. It is impossible for manager to express a business decision unless preferred decision can be expressed some outward way. What steps manager(s) take when they make a good decision? What 'traps' manager(s) stride into when making bad (or short-sighted) decisions? How to recognise a bad decision that appears to be good? Scientific debate over whether subjective experiences of emotion are functional or maladaptive has been ongoing (Gohm and Clore; 2002). Some argue that 'feelings' are source of unwanted bias (Shiv, Loewenstein, Bechara, Damasio and Damasio; 2005 and Slovic, Finucane, Peters and MacGregor; 2002) and need to be regulated (Gross and John; 2003). Others maintain that feelings play adaptive role in business decision (Damasio; 1994, Aspinwall and Taylor; 1997 and Fredrickson, 2001). On somatic markers, Dr. David Eagleman (year not known) opines, 'when something bad happens, brain leverages entire body (heart rate, contraction of gut and weakness of muscles) to register that feeling which becomes associated with event. When event is pondered, brain runs a simulation, reliving physical feelings of event. Those feelings serve to navigate, or at least bias, subsequent business decision. If feelings are bad, they dissuade action. If they are good, they encourage' in microseconds. Review by Thanh Pham (year not mentioned in an interview) on neuromanagerial 'business decision traps' indicate that most managers commit some kinds of errors and explore components of those errors and steps to rectify.

Common barriers encountered are:

- Plunging in (Gather information to reach conclusion without taking crux of issue).
- Frame blindness (Setting to solve wrong problem because of mental framework).
- Lack of Frame control (Failing to define problem by undue influenced by others).
- Overconfidence (Failing to collect key information).
- Shortsighted Shortcuts (Relying on 'rules of thumb').
- Shooting from Hip (Believing we can all information).
- Group Failure (Assuming that with smart manager involved, good decisions follow).
- Fooling Ourselves (Failing to interpret evidence from past outcomes).
- Not Keeping Track (Assuming that experience will make lessons available automatically)
- Failure to Audit (Failing to create approach for understanding business decision).

Neuromanagerial decisions making can be fragmented into four main elements:-

- Framing - Structuring the Question: What must be decided in preliminary way what criteria would cause manager to prefer one option over another.
- Gather Intelligence: Seeking knowable facts and reasonable estimates of 'unknowable' needed to make decision.
- Coming to Conclusion: Sound framing and good intelligence do not guarantee wise managerial decision.

- Learning from Feedback: Everyone needs to establish a system for learning from results of past decision.

While all business decisions are a guess about future, as complexity builds upon complexity, managers must increasingly rely on intuition and judgment. Central argument is that business decision is at core of managerial functions. Nonetheless, there are certain critical issues viz. uncertainties, multiple objectives, interactive complexity and anxiety that make business decision process difficult. Four critical observations are reference dependence, lack of absolute measure in brain, stochasticity in business decision and influence of learning on business decision. Stochasticity is a discrepancy between agent and environment due to external randomness and cannot be eliminated through further observation or designing organism differently (Satpathy; 2015). Even when granted full causal knowledge of governing observations; physical probabilities (Giere; 1999), propensities (Popper; 1959) or a priori probabilities (Knight; 1921), agent still make errors when predicting events under conditions of stochasticity (Brighton and Gigerenzer; 2012). Combining techniques from neuromanagement and experimental management, researchers watch neural activity in real-time, observe how this depends on management environment and test hypotheses about how emergent mind makes business decisions (Satpathy; 2015).

Neurobusiness decision allows understanding wide range of heterogeneity in managerial behaviour as ordered extensions of mind. Can management rewrite the past? Questions include; how to choose in tough situations where stakes are high and there are multiple conflicting objectives? How should managers plan? How can managers deal with risks and uncertainties? How can we create options that are better than originally available ones? How can managers become better business decision makers? What resources will be invested in managerial decision? What are the potential responses to a particular problem or opportunity? Who will make this business decision? Every prospective action has strengths and weaknesses; how should they be evaluated? How will they decide? Which of the things that could happen would happen? How can Managers ensure business decision will be carried out? These questions are crucial for understanding complex managerial behaviours (Satpathy; 2015). How can managers leverage brain in business decisions? How can managers capitalise / invest on brain? How can managers make 'best business decision'? How can managers find productivity 'hot buttons' in brain? How can managers encourage creative and ethical brain? What is the nature of explanation in managerial

decisions? What information about past is relevant? Is representation of past in any sense 'rational'? In almost all reviews, within judgment and decision approach, experience has been shown to be unrelated to empirical accuracy of expert judgments' (Hammond, 1996). What past experiences cannot be 'unlearned'? How does experience influence managers decisions? What kinds of experiences would produce better decisions and adaptation? How does experience transfer to new situations?

Managerial behaviour is sequencing. Sequentiality, in managerial behaviour, is forced physiologically. Sequence penetrates the corporeal boundary. sequence in activity (perception) is not disrupted / altered across corporeal boundary: a sequence 'within' is that same sequence externally (and vice versa). Sequence is semiotically free. What learning processes take place during sampling and repeated consequential business decisions? When is business decisions time - dependent? How do managers address consequential and sampling business decisions when 'environment' is dynamic? When business decisions are time - dependent? How do managers address consequential and sampling business decisions when 'environment' is dynamic? How do managers make business decisions in dynamic management tasks? How do managers perceive accumulation over time? Why do some managers perform so poorly at control tasks? How can judgments of accumulation be improved? How are theories represented in computational models? How can managers validate and test theories / hypotheses with computational models? How do managers make inferences from numbers? How do managers process logic representations of data relationships? Is representation of past 'rational'? What can and cannot managers expect of scientific modeling in managerial decision? Does managerial neuro - management have ontologically sound domain? Complete answers cannot be given in situ. However, empirical findings put limits to concept and indicate in which direction further inquiry should go (Satpathy; 2015).

Computational explanations appeal to computational models, in contrast to equations or axioms, to explain target systems. These are typically inspired by natural phenomena and 'natural computation' has been used in literature. Darwinian or evolutionary models and explanations are a prominent form (Kimbrough; 2002). Scott Linderman (2012) opines that 'computational neuromanagement' has two definitions. One, study of computational capabilities of brain, algorithmic details and implementation in neural circuits. Two, is design

and application of computational algorithms, either to solve problems in a biologically inspired manner or aid in processing and interpretation of neural data? 'Forward hypothesis' generation seems unlikely to get details right without aid of computational tools for extracting patterns from neural recordings, guiding hypothesis generation and comparing evidence for competing models. Attempts to infer fundamentals of neural computation from bottom-up without strong inductive biases appear doomed to wander vastness of hypothesis space. How to contribute towards 'computational neuromanagement'? Ultimately, brain as biological computation device, should fall within purview of computation. Though quite different, these are complementary and arguably, co - dependent endeavours. Nobel Laureate Herbert Simon remarked 'there is complete lack of evidence that, in actual (human) business decision situations of any complexity, (rational) computations can be, or are in fact, performed but we cannot, of course, rule out the possibility that the unconscious is a better business decision maker than the conscious'. Researchers' model business decision process under uncertainty as a problem in maximisation governed by mental processes and traces of which have observable neural correlates in brain imaging. Current modeling attempts breathe meaning into unconscious computational processes associated with business decision under uncertainty, inherent error properties and observational content.

Moreover, it offers substantial extension to interpretation that 'if subjects implicitly take explanation of effort cost of business decision, then subject's unconscious business decisions are better - super rational - than conscious rational business decision scrutiny predictions of the theorist / experimentalist'. Notion provides simple and testable setup for a scheme of business decision process. 'The essence of the situation is action according to opinion, of greater or less foundation and value, neither entire ignorance nor complete and perfect information, but partial knowledge. If we (researchers) are to understand workings of system we (researchers) must examine meaning / significance of uncertainty and nature / function of knowledge itself is necessary' (Frank H. Knight; 1921). It suggests new direction of research in investigation of emotional and neural foundation of difference between effects that function through improvement in signal and those operating through reduction of information processing cost.

'Open Questions'

Neuromanagement decision - making employs methods to investigate concepts drawn from managerial sciences. Studies select variables from psy-

chomanagement models, manipulates or 'measures' business decisions within simplified business decision task and identifies 'neural correlates'. Using this approach, scholars describe brain systems whose functioning shapes 'key variables'. Important aspects of the mechanisms remain moderately understood. These provide insights into mechanisms that underlie range of managerial phenomena. Paramount realisations lie within identifying and mapping 'neural indicators'. 'Cognitive maps' are related to 'concept maps' ('mind maps'). In 'mind maps', though links can have any meaning, while in cognitive maps, 'links' are 'causal'. Eden and Ackeman's work primarily focuses on context of business decision - making strategies. Canonical results include linking of 'neuron activity' (Schultz; 1997), generality of signals (Delgado; 2000), stimuli and interpersonal interactions (Sanfey; 2003) and identification of 'neural markers' for transactions (Padoa - Schioppa; 2006 and Plassmann; 2007). Signals are simultaneously and automatically computed for complex stimuli (Hare; 2008, Lebreton; 2009 and Smith; 2010).

One challenge is to develop process models that apply outside lab and complex challenges. Specifically, models provide valid descriptions of cognitive processes that are cognitively plausible and compatible with findings from controlled and simplified experimental paradigms. These are sufficiently general to apply them to real - world problems that involve communication between different agents, sense making based on unreliable or missing information and other complications. Coherence - based approaches provide framework that allow addressing challenges. They rest on the assumption that information processing can be described as process of active information - structuring and sense - making. In this, coherent interpretations are formed by taking into account incoming current evidence (bottom up effects) as well as prior knowledge (top down effects). Many models assume that this process can be modeled as spread of activation and interactive competition in network models. In contrast to established models and standard rational utility - maximisation approaches, coherence - based approaches break with the basic idea that information processing is conducted in a serial, step -wise manner by applying (a set of simple) business decision rules.

Reviews

'All management rests on some sort of implicit psychology. The only question is whether the implicit psychology is good or bad. We think it is simply unwise, and inefficient, to do

management without paying some attention to
good psychology'
..... Camerer and Loewenstein (2002)

Queries in Neurobusiness Decision Spectrum

Since its inception, more than a quarter Century ago, philosophy of neuroscience has grown into a recognised field in philosophy of special sciences. It focuses on foundational issues in the discipline, anticipates developments in neurosciences that bear on epistemological, ethical and cultural concerns. In this, managers are introduced to three issues. One, new version of old reductionism vs. integrations debate spurred by 'new mechanist' philosophers of neuroscience. The debate turns on the viability and extent of nested hierarchies of mechanisms in neuroscience. Two, challenge to 'dynamics' explanations in neuroscience, as covertly mechanistic or non - explanatory. Three, brief introduction to burgeoning field of neuroethics which is finding new discoveries that bear on both familiar ethical debates and generate novel concerns.

There is growing interest in exploring potential links between human biology and management and managerial studies bringing greater attention to bear on the place of mental processes in explaining managerial behaviour and effectiveness. While remarkable scientific progress in neuromanagement is beyond dispute, there are many doubts and concerns about (proposed) relevance of neuromanagement for managements (Bennett - Hacker; 2003, Legrenzi - Umilta; 2011, Satel - Lilienfeld; 2013 and Tallis; 2014). Within philosophy, two sub - disciplines attempt to deal with problems and prospects brought about by neuromanagement. Philosophy of neuromanagement tries to apply classical questions and models from philosophy of management to neuromanagement to shed light on specific explanatory strategies. Whereas this is considered skeptical or destructive, neurophilosophy takes another contour. Findings are applied to issues such as 'emotion' (Bermond; 2008), 'morality' (Walter; 2004 and Churchland; 2011) or 'consciousness' (Mandik; 2007) to gain empirically informed concepts and theories (Jungert; 2015). Issues are; which methods / theoretical assumptions are used in neurophilosophy and philosophy of neuromanagement respectively? What are the explanatory aims and theoretical basis of neurophilosophy's claim to integrate neuroscientific findings into philosophical model?

Briefly: what can philosophy learn from neuromanagement and vice versa? What makes these questions persisting is precisely that there is no way to settle them through empirical evidence. Rather, they are conceptual questions, some with

phenomenological aspects, and their solution lies in conceptual scrutiny and phenomenological reflection. This aspect has an interesting implication; if philosophical questions cannot be settled by empirical experimentation, this means that truth sought - after by the question does not make a difference to observation of how world causally works and consequently does not make a difference to causal interaction with it.

Overall, multi - dimensional and potentially integrative approach combines neurobiological, socio - Managerial and trans - cultural dimensions of business making and trust into a 'stratified image' of managerial behaviour(s). Of importance is the need to characterise interaction of physical, psychological, cultural and spiritual cognitions that establish various business decisions and which relate business decisional actions and outcomes. This explicitly neuro - bio - psycho - socio model encompasses at least six dimensions:

- Neural level that proposes neural networks involved in business decision - making,
- Biological attribute that describes evolutionary, developmental relevance of business decision,
- 'Anthropological' component that describes collective meaning as a self - conscious species among other (conscious) species,
- 'Psychological' aspect that provides definition pertinent to specific cognitions, emotions and character,
- 'Philosophical' dimension that regards rational dimension in sense of an in-depth scrutiny of causes and origins as related to effects, and
- 'Socio - managerial' dimension, that describes dependent inter - relations with others, respective past and present experiences.

Mechanistic details improve explanation of original socio - managerial scientific explanandum if knowledge effectively increases ability to make causal and explanatory inferences about the explanandum. This has rarely been the case in neuromanagement decision - making. Consequently, fact that some neural variables are directly manipulated does not necessarily mean that managerial decision - making relevant variables are been controlled. Moreover, argument that unlike emotional experiments, neuromanagement decision experiments obviate need for matching subject's and experimenter's models, and hence afford reliable causal inferences, overestimates current status of theories in business decision - making.

There are three co - dependent orders of brain / mind business decision - making crucial to under-

standing of business decision dynamics. One, internal order of mind and forte of neuromanagement from inception. Two, external order, which constitutes reciprocity and sharing norms. Three, extended order of cooperation (Smith; 2006). In absence of deeper examination of these, managers cannot distinguish between exchange and preference interpretations, understand why context is important in determining behaviour and understand how collaboration is affected by repeat play across same or different games, under different protocols. It is an empirical fact that natural managements have progressed only when they have taken secondary principles as their point of departure, instead of trying to discover essence of things (Busino; 1964). What do brain scans really tell us? What are the practical implications of this research?

Nakao et al. (2012) compares and disentangles two types of empirical protocols used for study of business decisional processes, experiments with unique but uncertain answer and experiments in which no unique external cued answer could be considered correct. The former is categorised as externally oriented business decision and later as internally oriented business decision. The paper compares externally and internally guided business decision – making empirically and theoretically, studies conceptual and operational differences plus similarities between both cases. In case of externally guided business decision, two types of experiments are analysed. One, tasks with difficult probabilistic outcome and two, experiments in which answer is varied (or believed to be varied). In case of internally guided business decision, experiments addressing preference judgment and business decision are encompassed. The paper uses Multi - Kernel Density Analysis (MKDA) to contrast internally and externally guided business decisions to compare commonalities and differences between the two types of business decisions. Along contributions to business decision - making, paper contributes to understanding brain's resting state and its high activity, especially in Default Mode Network (DMN) that overlaps with observed regions in internally guided business decision.

Research investigates neural bases of business decision predictability / value and central parameters in model of expected utility. Why might brain have evolved to compute value on a relative, rather than absolute scale? Among the gargantuan questions are; How do neurons code emotional weight of experiences? Do some neurons become active in response to negative experiences while other neurons only fire when they experience something favorable? How do neurons code numerical value of various options? Do more or different neurons

fire for 'option' with bigger rewards than that for a lesser reward? How does coding differ from that of that are delayed? How do far-flung parts of brain govern business decision - making? What triggers a business decision? Is it cumulative buildup of firing neurons that tip balance to final business decision? How do we alter business decision - making rules when we encounter new information that makes those rules obsolete? (Satpathy; 2015). Herbert Simon (1965) claims three elements or stages in making any business decision. They are, one, finding occasions for making a business decision / intelligence activity ('search activity'). Second, finding and analysing possible courses of action ('design activity'). Third, choosing a 'course of action' from among those available ('business decision activity'). These three reinforce that business decision - making is a process that leads to a business decision between two or more possible 'courses of action'.

Normative Modeling

Normative theories for cognition aim to tell how to ideally reason, make judgments and take business decisions. These theories, particularly formal logic, probability theory and business decision theory, give rules to follow or conform to that supposedly make thought rational. Assumption of normative models is that of rationality of manager. Generally, manager is rationale if he is non - contradictory. Second assumption is that manager knows all alternatives and selects optimal course of action. Other authors add the hypotheses; number of managers and unanimity of objectives. Number of managers represents an important issue. Some authors consider that manager represents core of normative models 'unique actor'. Unique actor means that a single manager or a group of managers that act together, having a common objective, take business decision (UK Essays: Linda; 2015). There are no conflicts on objectives or business decision - making process. Hypotheses of normative models are ideatic, hard to be identified in business decision - making context. G. S. Becker notes: 'While for a long time traditional management theory presumed that human behaviour is rational, at certain moment there was major contradiction regarding meaning of concept 'rational'. For many manager(s) the word 'rational' suggested an old psychology, fast calculus abilities, hedonist motivation and possible unrealistic behaviour. While management philosophy became clear and precisely formulated, controversies diminished and now everybody agrees that rational behaviour implies permanent maximisation of defined functions' (UK Essays: Linda; 2015).

Descriptive Modeling

Descriptive theories describe how to actually think. Descriptive results showing that managers are out of line with a suggested normative rule may be grounds for concluding that their thinking is fallacious or biased. Descriptive models suggest that difficulty to obtain information and limits of processing complicate business decision - making process. In category of models, scholars identify models such as, satisfaction model, incremental model, garbage can model etc. In 50s, Herbert Simon began to study real behaviour of managers and proposed the model of 'administrative man' that acts based on 'limited rationality'. While 'management man' maximise by choosing 'best alternative', 'administrative man' formulates aspiration regarding alternative that need to be identified. When this aspiration is met, search is over and respective alternative is selected as business decision. This is the essence of 'satisfaction model' based on limited rationality. George P. Huber considers that managers usually become accustomed with a simplistic approach. It is important to be noticed that satisfaction model leads to a 'rush business decision' and 'solution' found is, in many cases, a trap hard to avoid (UK Essays: Linda; 2015).

How can findings of emotional management be incorporated within mathematical framework? Whether mathematically explicit theories from management should be mapped to those from neurobiology homomorphically albeit preserving their mathematical or logical structure? Wierzbicki (1982) presents a conceptual / mathematical model of business decision under multiple objectives in which information about manager's preferences is expressed in form of aspiration levels. It is shown that mathematical basis formed using aspiration levels and achievement - scalarising functions can be used not only for satisficing business decision - making but for Pareto optimization and provides alternative to approaches based on weighting coefficients or typical value functions. Mathematical concept of a value (utility) function is modified to describe satisficing behaviour; modified value function (achievement scalarising function) that possesses properties of order preservation and order approximation. This basis, which can be regarded as a generalisation of goal programming approach in multiobjective optimisation, suggests pragmatic approaches to problems in multiobjective scrutiny. Issues are; is maximisation of a value (utility) function an adequate model for typical business decision - making processes? If various institutional aspects restrict rationality of business decision, how do we best model business decision - making process mathematically?

Models are meant to establish 'linkages' between concepts and statements that appear in judicious management situations (Rubenstein; 1998). After Simon, James G. March focuses on business decision - making is a process that can be perceived via complexity and ambiguity of contexts, present but underestimated. In these conditions, March, with D. K. Cohen and J. P. Olsen has proposed 'model of garbage'. In this model, managers have random behaviour, quite non - scientific, in non - programmed business decision situations (UK Essays: Linda; 2015). Strategy used when manager does not have preferred objective. This kind of approach can be observed when it lacks a solid strategic management. Outcomes, when using this model, are mixed: sometimes favourable but, in many cases, consequences are not favourable.

A third model is 'incremental model' according to which managers make efforts to reduce business decision situation to 'tolerable' level. Business decisions are made to reach 'palliative' objective, solving short - term problem instead of tackling long - term issues. The model does not motivate managers to process large quantity of information to elaborate business decision. Incremental vision business decision developed by Charles Lindblom describes two approaches used in business decision process. One, 'comprehensive rationale method' and two, 'method of limited successive comparisons'. The 'comprehensive rationale method', or 'root approach', is similar with normative models of business decision - making. Following root approach, manager can clearly spot objectives relevant for business decision. Manager identifies compensations that can be made among objectives, in which gains compensate loses (UK Essays: Linda; 2015). According to 'root approach', manager is considered to have knowledge about set of alternative solutions and consequences of applying solutions. Based on this, a large number of business decisional alternatives are compared and alternative chosen is the one that satisfy the objective.

Two central assumptions underlie all business decisional capacity. First, business decision - making capacity is business decision 'relative' (Buchanan and Brock; 1989). Second, business decision - making capacity is a 'threshold' (Buchanan and Brock; 1989). Basic elements of capacity (and their rationale) are understanding, appreciation (of nature and significance of business decision faced with), reasoning, business decision and values. Capacity limitation stressed by information processing metaphor is a limitation in cognitive capacity. Focusing solely on these limitations ignores crucial role played by environment in shaping managerial behaviour (Simon; 1956). To

model cognition, researchers must understand connection between limitations imposed by mind and those imposed by situation. A scissors whose blades are structure of task environments and computational capabilities of actor shapes human rational behaviour (Simon; 1990).

The root approach opines that mental capacity of manager is not large enough to confront an avalanche of information and alternatives involved. In practice, manager is not confronted with intense mental efforts. This is because information is incomplete and inadequate. In case of limited successive comparisons or 'branch' approach, manager identifies alternatives to solve problems. The identified alternative is chosen, that is relatively easy to be implemented. If there is need for improvement, process starts to deliver a pragmatic feature to business decision - making taking into consideration the limited ability of manager (UK Essays: Linda; 2015).

What are the limits? Computational theory holds that mind is a computation that arises from brain acting as a computing machine. Theory can be expounded in ways that brain is a computer and mind is result of programme that brain runs. Computational theory views that human mind or brain (or both) is information - processing scheme and thinking is a form of computing. Is universe naturally symmetric or do brains stare for symmetry that then become reality? Why are manager's symmetric beings? Would an irregular intelligent manager find a different looking universe based on asymmetrical laws? A manager is not a single entity of a single mind but built of several parts, all of which compete to steer 'ship of state'. Consequently, manager(s) are nuanced, complicated plus contradictory and act in ways that are sometimes difficult to detect by simple introspection. Do unconscious processes govern managers? Neuromanagement believes so. This requires thinking at multiple levels of abstraction that may be more than computing. What follows is description of some scientific, philosophical and practical issues that lead inevitability to uncertainty in data and limitations in ability to draw conclusions. Such queries are complex, uncertain and presumably consist in a departure from completely disciplined behaviour involved in computation.

How does previous experience alter behaviour? : Called 'dilemma of determinism', managers do not know if actions are controlled by causal chain of preceding events (or by some other external influence), or if managers are truly free agents making business decisions of their own volition. Philosophers (and Researchers) have been debating this for millennia with no apparent end in sight. If

business decision is influenced by endless chain of causality, then determinism is true and managers do not have free will. However, if opposite is true, what is called 'indeterminism', then managerial actions must be random, what some argue is still not free will. Conversely, libertarians make case for 'compatibilism', idea that free will is logically compatible with deterministic views of universe. Compounding the problem are advances in neuroscience showing that brains make business decisions before managers are even conscious of. Quantum mechanism makes this problem more complicated by suggesting that managers live in a universe of probability and determinism of any sort is impossible (Dvorsky; 2012). In addition, as Vepstas has said, 'Consciousness seems to be intimately and inescapably tied to perception of passage of time, idea that past is fixed and perfectly deterministic and that future is unknowable. This fits well, because if future were predetermined, then there would be no free will, and no point in participation of passage of time

Many real - life decision contexts are sequential in nature and hence give rise to the possibility of one business decision influencing a subsequent one. Business decisions managers make are based on memories, not experiences. Researchers have shown that past experience help when managers have to make complex business decisions based on uncertain or confusing information. They show that learning from experience actually changes the circuitry in brains so that we can quickly categorize what we are seeing and make a business decision or carry out appropriate actions. Behaviour results from complex interactions between genetic and situational components. Every manager has unique collection of experiences to draw upon. Observed tendency to re-choose an alternative is due to a change in attitude in favour of that alternative. Consequently, they behave slightly differently in a similar situation. This makes disentangling genetic components of behaviour challenging.

Brain appears to employ two general strategies for decision; one, relying on previous reinforcement and other based on flexible prospective reasoning about consequences of actions. Under the first strategy, actions are valued by rewards they have previously produced, as postulated in Thorndike's law of effect and formalised in model - free reinforcement learning. In contrast, under second strategy, choices reflect knowledge of task contingencies or structure and outcomes that might be realised, as demonstrated when navigating new paths in a spatial maze or generalising from known relationships to those that were never directly learned. Such learning, formalised by model - based reinforcement learning theories, allows flex-

ible evaluation of changing options. Business decisions may arise via 'model - free' repetition of previously reinforced actions or by 'model -based' evaluation, which is widely thought to follow from prospective anticipation of action consequences using learned map or model. While choices and neural correlates of business decision variables sometimes reflect knowledge of consequences, it remains unclear whether this actually arises from prospective evaluation. Using functional magnetic resonance imaging and sequential reward - learning task in which paths contained decodable object categories, Bradley et. al (2015) found that humans' model-based choices were associated with neural signatures of future paths observed at business decision time, suggesting a prospective mechanism for choice. Prospection covaried with degree of model-based influences on neural correlates of business decision variables and was inversely related to prediction error signals thought to underlie model-free learning. These dissociate separate mechanisms underlying model - based and model - free evaluation and support the hypothesis that model-based influences on choices and neural business decision variables result from prospection.

Traditional models assume optimal (Bayesian) updating. However, emotional theory suggests that managers exhibit bias in their beliefs and business decisions. Experiences are defined by change. Previous work largely ignores internal neuronal activities representing prior knowledge that occurred before a new event, space or situation. Intriguing questions concerns manner in which nervous scheme can modify and ultimately its function throughout a manager's lifetime. It is presumed that experiences have different effects on behaviour than similar experiences later. Accurate detection and cognitive processing of sensory cues release appropriate emotional, physical or physiological response to initiate behaviour. This is influenced by learning and memory.

Deneve (2012) presents an elegant Bayesian business decision model that both infers probability of two different choices and simultaneously estimates reliability of sensory information on which this choice is based. Trials in which level of difficulty is higher show early sensory inputs having stronger impact on business decision. Accordingly, threshold collapses such that response time is shorter, though with lower accuracy. Easy trials, by their turn, show the opposite: increased sensory weight and higher threshold over time, eliciting slower, but more accurate, business decisions. As model considers adaptive sensory weights, it could not only extract a single estimate from the sensory input, but evaluate uncertainty associated with it.

That would be an advantage in comparison to standard diffusion models (Ratcliff and McKoon; 2008), as it would allow optimal combination with other noisy sensory cues. Bayesian model is especially successful when it is possible to encompass prior knowledge with sensory evidence. This is open to further investigation whether the phenomenon is due to subjects being less trained or because humans may use other cues to evaluate sensory reliability, not allowing for adaptive sensory gain as, from beginning, near optimal value are already achieved.

The above findings explain a neuronal circuit through which prior knowledge influences business decisions in a new situation. This explains, in part, why different managers form different representations and respond differently when faced with same situation. In selecting course of action that is most likely to be successful, brain has to interpret and assign meaning to inherently uncertain sensory information. Being able to do this is vital for survival. This ability is especially critical when managers are responding and acting in relation to visual stimuli highly similar to each other. 'What we have found is that learning from past experience actually rewires our brains so that we can categorise the things we are looking at, and respond appropriately to them in any context' (Dr Zoe Kourtzi; 2009).

What are the general implications?

Human reasoning is accompanied by metacognitive experiences, ease or difficulty of recall and thought generation and fluency with which new information can be processed. These experiences are informative and serve as basis of judgment in addition to, or at expense of, declarative information and qualifies conclusions drawn from recalled content. What exactly managers conclude from given metacognitive experience depends on naive theory of mental processes they bring to bear, rendering outcomes highly variable. Obtained judgments cannot be predicted on basis of accessible declarative information alone. 'We cannot understand human judgment without taking into account the interplay of declarative and experiential information' (Schwarz; 2004). Management has always relied on careful modeling of business decision modeling.

New brain imaging technologies have motivated neuro - managerial decision studies of internal order of mind and links within spectrum of managerial decisions mediated by institutional rules. Researchers are at beginning of an inventiveness, but its promise suggests a fundamental change in how managers think, observe and model managerial decision in all its contexts (Smith; 2002). In

order to explain cognitive and neural basis of decisions, ability to process multiple alternatives and choose optimal course of action, especially in a managerial context. Growing number of researchers have combined research methods from neuromanagement, experimental and emotional management, cognitive psychology. In addition, neuromanagement, nerve management emphasis on specific situations, manager differences and operational level of behaviour, study different conditions managed object evolution rule and achieve effective management method. Nerve management specific subjects include neural business decision management, neural marketing personnel management, neural, neural engineering, emotional neuromanagement, neural finance innovation management, nerve, nerve pathological behaviour management. Use of this methodology has potential to advance knowledge of existing theoretical accounts of how manager(s) make business decisions and judgments by informing and constraining models based on underlying neurobiology. Examining sophisticated high - level behaviour at neural level, such as deciding on how much risk to take, provide important clues as to fundamental mechanisms by which managerial decision - making operates. Despite substantial advances, question of how we make managerial decisions and judgments continues to pose important challenges for scientific research (Satpathy; 2015).

Some managerial behaviour patently fails to achieve the goals, leading to downfall of managers responsible for them and sometimes to failure of entire organisation. Neuro - managerial decision standard management assumption that business decision - making is a unitary process; a simple matter of integrated and coherent utility maximisation. Goal is a mathematical model of how brain implements business decisions that is tied to behaviour. This theory (Satpathy; 2015) is likely to show some business decisions for which rational - decision is a good approximation (particularly for evolutionarily sculpted or highly learned business decision), provide deeper level of distinction among competing alternatives and provide empirical inspiration to incorporate nuanced ideas about endogeneity of preferences, manager difference, emotions and endogenous regulation (Satpathy; 2015). Researches investigate central parameters viz. neural bases of business decision predictability and value in theory of expected utility.

Apart from classical approaches, there are new developments of business decision - making models. In a review, Mintzberg and Westley (ed. 2015) describe three models of business decision models based on reflection ('thinking first model'), model based on vision ('seeing first model') and model

based on action ('doing first model'). The model, based on reflection, is a rational model to which authors find series of limits. First, because it is a theoretical model without larger practical application. Second, considering this, authors propose two new sub - models. The model based, on vision, suggests that business decision or actions can be oriented by imagination, anticipation rather than reflection. Vision requires courage to see what others do not see. Third model proposed is a model based on action. Many managers consider that is much more important to act, after which to analyse this experience and to learn from mistakes. We can learn both from success and from failures. When the preoccupation for reflection, in order to act according to a well - established plan, becomes an obsession, learning by doing can be discouraged.

Two new concepts need to be clarified to fully understand the above models, respectively; 'imagination' and 'intuition'. Imagination is mental faculty allowing elaboration of new associations by composing and decomposing ideas, by combination and recombination, in end creating objects, situations that never existed in nature. Intuition refers to tendency to reach a conclusion or fulfill action without detailed explications regarding each step of process. Intuitive model of business decision - making is not approached in a universal manner, thou exists many dispersed approaches. Authors admit that intuition play powerful role in business decision - making process without describing exact nature of these influences. There is evidence for reliable manager differences in tendency to use intuitive (spontaneous, affect-based) and deliberative (effortful, planned and analytic) business decision mode. Even though other manager characteristics in business decision - making (risk attitude) seem to be domain - specific, it is commonly presumed that manager's business decision style is relatively stable across business decision domains. There are theorists who suggest that intuition should always be used as an adjunct to empirical or rational decision models. Ward (2009) suggests that learning to harness one's instincts and intuition helps managers.

Saget (year not mentioned), in his review 'The intuitive manager' considers that in an ever complex environment there is a tendency toward simplicity, toward what is easy accessible, toward fast understanding. There is the need to equilibrate logic and analytic thinking by another form of reasoning that will allow to immediately clutching a situation: an 'intuitive reasoning'. Vaughan (year not mentioned), considers that intuition is a psychological function that each manager poses at acceptable level. Jung (year not mentioned), believed that intuition should not be regarded in an

tithesis with rationality, only being different. Intuition is defined by some as being more sophisticated type of rationality based on 'illumination', belonging to some specialists with experience in a certain area.

Agor (year not mentioned), believes that 'intuition, when developed, represents effective way toward knowledge. It is fast and of high accuracy. System processes a large volume of information, from different levels and offer signals regarding possible way of actions.' Agor considers that intuition is a 'business decisional ability with pronounced rational character - subspecies of logical reasoning hidden in unconscious part of brain'. Karl Weick (year not mentioned), appreciates that intuition is a 'condensed experience' synthesising quite powerful the way in which accumulation of information seem to be the manifestation of unconscious. There is a difference between intuition of manager dominated by emotions and intuition of experts. Intuition of experts is the result of learning, of experience while the first is result of basic emotions that diminish attention. It will be a grave confusion to overlap non - rational business decision that results from intuition of expert with irrational business decision that can be generated and negative flows of emotions.

'It is doubtful that we will find two types of managers (at least, of good managers), one of whom relies almost exclusively on intuition, other on analytic techniques. More likely, we will find continuum of business decision - making styles involving intimate combination of two kinds of skill. We will likely find that nature of the problem to be solved will be principal determinant of the mix' (Simon; 1987). In many cases, intuition is overestimated, being used to justify that there is no longer need for self - discipline and rigour, in the logic of 'if this is what you feel then this is good for you'. Pushed to extreme, this tendency destroys contact with reality. Intuition should be construed as complement of rational thinking and not as replacement. This method is used when manager has not met with similar business decisional context and he does not know other similar experiences of other managers. This works when there are alternatives viable that are difficult to evaluate with other tools. In addition, imagination can affect business decision process. Related to business decision - process, imagination can be used to reach some objectives into a negotiation process, in solving interpersonal conflicts, in building consensus, establishing objectives, evaluation of general conditions and solving abstract problems.

Tannenbaum (year not mentioned), considers that 'creativity' is a useful process for business

decision - making situations ensuring better communication, allowing better investigation of problem and development of new ideas, solutions and alternatives. Development of this issue belongs to Edward de Bono in his work 'Lateral thinking'. In his opinion: 'purpose of reasoning is to get information and use them in most efficient possible way. Vertical reasoning deals with the creation of conceptual models. Lateral thinking deals with restructuration of these models (intuition) and determination of new models (creativity). Lateral thinking and vertical thinking go together in 'complementary fashion'. Bono has identified synthesis in which creativity can help business decision - making. He believes that there are three types of problems. First type of problem requires more information and better techniques to handle information in order to find solutions. Second type of problems does not require new information but redistribution of existing information ('intuitive restructuration'). Third type is that existing arrangement is optimal and this stops the search for better one. Second and third type of problems requires use of lateral thinking to discover solution.

Gelatt (year not mentioned) introduces notion of 'positive uncertainty'. Uncertainty present in quasi business decision contexts should no longer be something manager must worry about but embark on positive attitude. Based on this, there are options for manager and he can manifest 'proactive creativity'. Reasoning is simple. If manager is positive about what to follow, then he things only about this possibility and under no perturbations this will actually happen. When manager is uncertain about what will follow then he is free and capable of studying alternatives. In this case, he needs a model of creative business decision - making. Manager requires flexibility saying 'If you know exactly where you want to go you will never get somewhere else'. In this context, we have to mention that emotions of manager have a strong impact in configuration of business decision - making process. These can affect optimal business decision - making by distracting attention or by distorting perception over options'.

Neuro - Decision Models

Neuro - managerial decision has arisen quickly as subfield within management, but does not exhibit a unified methodology. The general distinction is between what Ross (2008) calls 'neurocellular management' (NE) and 'emotional business decision' in scanner' (BDS). Although researchers are generally skeptical about BDS, identification of problems with neurobusiness decision that need attention is intended practically. This calls for critical reviews on methodological practices of

‘neuro - managerial decision’. Researchers defend ‘neurocellular management’ from attack on relevance by Gul and Pesendorfer (2008). This attack arbitrarily singles out some but not all processing variables as unimportant to management, insensitive to realities of empirical theory testing and ignores central importance of ‘ecological rationality’ (Smith 2007). Researchers consider grounds for skepticism based on methodological individualism, ad hoc business decision metrics, tolerance for invalid reverse inference and inattention to difficulties involved in extracting temporally lagged data (Glenn and Ross; 2005). Issue in question is distinction between ‘reflective’ and ‘formative’ constructs. former are diagnosed or indicated by sets of observable markers, which are each supposed to perfectly reflect single underlying latent variable. Such constructs are based on factor scrutiny, used to discover high - loading items and reject low-loading ones, rather than on structural modeling. Formative constructs, by contrast, have logical character of dependent variables in business decision models. That is, they summarise interactions of range of independent (perhaps causally linked) variables (Glenn and Ross; 2005).

Technological and scientific progress in ‘brain sciences’ discourse empirically fundamental inquiries of ‘mind sciences’. Neuroimaging techniques have recently been used to examine neural mechanism of business decision. Nevertheless, most neuroimaging studies overlook importance of autonomic response in modulating process of business decision (Wong; 2011). Neuroeconomic research programmes would consequently do well to employ combination of methods that can address questions of association, necessity and sufficiency. Second, given strengths of multi - method approach, does current research in neuromanagement actually use this approach? Given plethora of neuroscience techniques available, what kind of methodological approach should research in neuromanagement take? While several introductions to the field recommend a multi - method approach (Camerer; 2007, Camerer, Loewenstein and Prelec; 2004, Camerer, Loewenstein and Prelec, 2005), this overview emphasises particular strength of using multiple methods. This review provides introductory overview to different methods used in managerial neuroscience. It describes basic strengths and weaknesses of each technique, points to examples of how each technique has been used and provides key references. In addition, review presents framework that organises managerial neuroscience methods functionally, according to whether they provide tests of association between brain activity and cognition or behaviour, or whether they test necessity or sufficiency of brain activity for cognition and behaviour (Joseph W.

Kable; 2011). This demonstrates utility of a multi - method approach, because converging evidence from tests of association, necessity and sufficiency provides strongest inference regarding brain - behaviour relationships. Set against this goal of converging evidence, managerial neuroscience studies in neuromanagement currently rely far too heavily on methods that test association, most notably (Joseph W. Kable ; 2011) functional magnetic resonance imaging (fMRI).

Functional MRI (fMRI): fMRI is a type of functional brain imaging technology using MRI technology that measures brain activity by detecting associated changes in blood flow. It localises regions of activity in brain by measuring blood flow and / or metabolism following task activation to identify areas of sensorimotor function (sensorimotor cortex). This technique relies on the fact that cerebral blood flow and neuronal activation are coupled. fMRI concept builds on earlier MRI scanning technology and discovery of properties of oxygen-rich blood (Wikipedia). fMRI study consists of four key steps:

- (1) Formulating research question,
- (2) Designing fMRI protocol,
- (3) Analysing fMRI data, and
- (4) Interpreting and reporting fMRI results.

MRI brain scans use strong, permanent, static magnetic field to align nuclei in brain region being considered. Another magnetic field, ‘gradient field’, is applied to kick nuclei to higher magnetisation levels, with effect depending on where they are located. When gradient field is removed, nuclei go back to original states, and energy they emit is measured to recreate positions of nuclei. MRI thus endow with static structural view of brain matter. The central thrust behind fMRI is to extend MRI to capture functional changes in brain caused by neuronal activity.

Magneto Encephalography (MEG): Magneto Encephalography is a functional neuroimaging technique for mapping brain activity by recording magnetic produced by electrical currents occurring naturally in brain, using sensitive magnetometers. Electrocardiography (ECG) is process of recording electrical activity of heart over a period using electrodes. Transcranial Direct Current Stimulation (tDCS) is form of neuro - stimulation that uses constant, low current delivered to brain area of interest via electrodes on scalp (Wikipedia).

Electroencephalography (EEG): Electroencephalography (EEG) is a non - invasive (however invasive electrodes are often used in exact applica-

tions) method to record electrical activity of brain along scalp. Scalp EEG represents aggregates of post - synaptic currents of millions of neurons. Recorded EEG signals usually reflect two types ; spontaneous and event - related activities. Spontaneous EEG reflects neuronal responses that occur unprovoked, in absence of any identifiable stimulus, with or without emotional manifestations (Williamson, Kaufman, Lu, Wang and Karron; 1997, Ergenoglu et al.; 2004 and Romei et al.; 2008). In addition, spontaneous EEG may hold key to unraveling patterns of functional connectivity and synchronicity among brain regions underlying states of consciousness (default network) (Mantini; 2007). By combining with resting - state fMRI, generators of spontaneous EEG activities can be localised (Salek-Haddadi; 2003).

Positron Emission Tomography (PET): Positron Emission Tomography (PET) is an imaging technique that produces three - dimensional image of functional processes in body (Wikipedia).

Transcranial Magnetic Stimulation (TMS): Transcranial Magnetic Stimulation is a noninvasive method used to stimulate small regions of brain (Wikipedia).

Eye Tracking: Eye Tracking is process of measuring either point of gaze (where one is looking) or motion of eye relative to head (Wikipedia). Process tracing (Glaholt; 2011) monitoring is a valuable tool for capturing business decision managers information search behaviours.

Electro Dermal Activity: Electro dermal Activity (EDA), or skin conductance, galvanic skin response (GSR), electro dermal response (EDR), psych galvanic reflex (PGR), skin conductance response (SCR) and skin conductance level (SCL) causes continuous variation in electrical characteristics of skin. Dawson (2011), in a study on skin conductance response, anticipation and business decision - making has reflected that cortical and subcortical mechanisms involved in expression of skin conductance response are identified in relation to business decision - making and related cognitive processes.

BOLD: Blood - Oxygen - Level Dependent Contrast Imaging, or BOLD - contrast imaging, is a method used in functional magnetic resonance imaging (fMRI) to observe different areas of brain or other organs, found to be active at any given time. Cognitive Maps are mental representations of physical locations. BOLD responses in surrounding voxels are usually averaged (through certain types of spatial filters) in order to increase

statistical power. BOLD responses are usually threshold to generate activation maps.

'Open Questions': Above methods sign management of complex and advanced product of brain. How strong is the discipline behind these discoveries to date? Interpretation of managerial activity in terms of neuromanagement is typically concerned with extreme behaviours. There are significant differences between the methods. Such differences include: extent to which business decision problem is broken into hierarchy of sub - problems, whether or not pair wise comparisons of substitutes and / or criteria are used to elicit business decision-makers' preferences, use of interval scale or ratio scale measurements of business decision-makers' preferences, number of criteria included, number of substitutes evaluated, ranging from a few (finite) to infinite, extent to which numerical scores are used to value and / or rank substitutes, extent to which incomplete rankings (relative to complete rankings) of substitutes are produced and extent to which uncertainty is modeled and analysed. There is sufficient overlap to motivate further investigation. Combining information obtained from structural and functional imaging methods is particularly powerful and by using such complimentary techniques, knowledge of both functioning and pathofunctioning can be enriched.

Turning to functioning, what physiognomies might one seek in neurons that play a role in business decision process? In principle, brain could contain neurons whose sole purpose is to form pronouncements about interpretations, liberated fluctuating detail in sensory stream or emotional option to be exercised. In fact, researchers know of no structure in brain that contains abstract representation of interpretation or business decision not tied to effector system or dependent on continued presence of sensory inducement (Summerfield; 2015). Rather, business decision process seems to emerge at nexus of sensory and motor processing; where sensory data give a plan to enact particular behaviour. Neural elements consequently tend to one side or other of what appears to be a sensory-motor continuum. Accordingly, a business decision - related neuron should modulate its response during acquisition of sensory information that leads to one interpretation or another. However, unlike a sensory neuron, it should continue to respond after cue is removed, just as business decisions can persist after sensory cue has vanished. Its response should herald a particular action that would designate one outcome and not another. However, unlike a motor neuron, its response should not oblige immediate movement, 'just what to do without acting impulsively' (Summerfield; 2015).

Is quality of managerial decision - making good, bad, or indifferent? There is no doubt that in some situations, managers deviate strongly from statistical optimality in judgments and exhibit inconsistent or irrational preferences. However, researchers argue that choices can be understood if information is encoded efficiently, with maximal sensitivity to business decision - relevant evidence that is likely to occur. Classic biases, including framing, anchoring effects and range - dependence of neural value encoding are explained in which gain of neural processing adapts to local situational context. When sensory input is rendered variable, volatile, or otherwise heterogenous, perceptual classification judgments come to exhibit similar sub - optimal context - dependence, consistent with notion that efficient coding of information is a general - purpose constraint on managerial decision-making (Summerfield; 2015).

In a study on managerial performance on perceptual classification tasks approaches that of an ideal observer,(Summerfield and Konstantinos Tsetsos; 2015) opine that economic business decisions are often inconsistent and intransitive, with preferences reversing according to the local context. We discuss the view that suboptimal choices may result from the efficient coding of business decision-relevant information, a strategy that allows expected inputs to be processed with higher gain than unexpected inputs. Efficient coding leads to 'robust' business decisions that depart from optimality but maximise the information transmitted by a limited-capacity system in a rapidly-changing world. We review recent work showing that when perceptual environments are variable or volatile, perceptual business decisions exhibit the same suboptimal context-dependence as economic choices, and we propose a general computational framework that accounts for findings across the two domains.

There are copious literature available in managerial decision-making area that purport to depict how managers in particular can and should make better business decisions (Arkes and Hammond; 1986, Baron; 1994, Bazerman; 1998, Beach;1993, Cooksey; 1996, Goldstein and Hogarth; 1997, Goodwin and Wright; 1991, Harrison; 1995, Hogarth; 1987, Jennings and Wattam; 1998, Kahneman et al.; 1982, Kleindorfer et al.; 1993, Payne et al.;1993, Plous;1993, Rowe and Boulgarides; 1992, Russo and Schoemaker; 1989, Shapira; 1997 and Yates; 1990). However, reasonable interpretation of any of these tends to lead to one or more of following conclusions:

- Business decision is or should be largely a rational managerial activity,

- Business decision - making usually proceeds in a linear sequence of stages,
- What managers know comes from controlled laboratory studies or simulations,
- Approaches are rather disjointed and discipline is not well integrated,
- Most approaches are highly abstract, quantitative theories requiring strong assumptions about regularity and predictability in managerial behaviour,
- Managers are often biased and error prone and limited in cognitive capacities, and
- It is possible for managers to make optimal decisions with aid of support system or procedure.

Unfortunately, these conclusions collectively fail to depict true complexity and dynamic nature of business decision (Cooksey; 2000). A further unfortunate outcome is that literature summarised in many of tends to be paradigm bound (business decision and utility analysis; heuristics and biases, attribution and information integration theory). Rather uncritical reporting of knowledge base on managerial decision - making covering other discipline areas in management (organisational behaviour, managerial resource management, management information systems, international business, general management, marketing management, operations research, strategy and management) further compounds this (Cooksey; 2000).

On literature listed, Harrison (1995), Kleindorfer et al. (1993), Payne et al. (1993), Rowe and Boulgarides (1992), and Shapira (1997) appear to do some justice to dynamism and context effects in business decision - making. Cooksey (1996) highlights some dynamics that may be involved in analysis of managerial judgment. However, these sources present only fragmentary and partial standpoints. That judgment and business decision research remains a fragmented and divided discipline is highlighted by Hammond (1997) and by earlier arguments presented by same author (1990, 1996). Some hallmark characteristics include laboratory vs. field or naturalistic focus, prescriptive / normative (axiomatic) vs. descriptive / naturalistic focus, coherence (agreement of business decision process with a normative set of rules, axioms, or procedures) vs. correspondence (empirical accuracy of judgment or business decision) focus, focus on errors vs. focus on adaptive successes and narrower focus on rationality vs. wider focus on rationality and intuition (Cooksey; 2000). This translates into selective importing of ideas into discussions of managerial decision - making, often to point of generating simplistic recommendations

about best or optimal method (linear in conception) for making 'rational' managerial decisions.

Acquainting managers with simplified and frequently tightly codified business decision procedures creates giant blind spots to contextual constraints and influences imposed in naturalistic business decision contexts (blind spots were highlighted in management lexicon by Cooksey et al.; 1998). Newer research (Cooksey; 2000) in naturalistic business decision - making and systems thinking confirms that study of business decision - making must be contextualised before serious theorising and understanding can occur (Klein et al.; 1993, Senge; 1990, Senge et al.; 1994 and Zsombok and Klein; 1997).

It seems clear that contextual factors must be explicitly embedded within any account of managerial decision - making process. This is, in part, because current business decision theories and approaches are context independent, have poor performance records as predictive devices for business decision outcomes and outcomes translate poorly from frequently idealised laboratory conditions under which they are tested to conditions that are more business decisions that are naturalistic where managerial are made (Klein et al.; 1993). Cooksey and Gates (1995) highlighted key roles that myriad of contextual factors play in appropriately complexifying what had been somewhat simplistic and static theories and approaches in discipline of managerial management. This standpoint can be extended to encompass managerial decision. Cooksey (1998) applied complexity standpoint to analysis of business decision. Cooksey (1996) began development of complexity standpoint for general and managerial decision. This initial development work is further modified and extended in presentation of a business decision audit tool to assist in implementing complexity standpoint (Cooksey; 2000).

Contrary to persistent pressure of law of parsimony, there are a number of reasons important to pursue complexifying standpoint in area of managerial decision. Developing such, a standpoint, helps avoid oversimplification and linear thinking. It can anchor business decision in its context, with all of its attendant complexity. It promotes method / data triangulation (Cooksey; 2000). Complex systems approaches demand variety of data types (quantitative and qualitative) and data sources (Churchman; 1971). It reinforces inescapable ideas that both managerial condition (Cooksey and Gates; 1995; Epstein; 1994 and Johnson, 1995), as well as task considerations (Brunswik; 1952; Cooksey; 1996 and Hammond; 1996), must be factored into business decision. Finally, it signals

the notion that high level of predictability in business decision outcomes cannot be expected or sustained, especially at manager level (Guastello; 1995 and Priesmeyer; 1992). Irving Janis's work (Janis; 1989 and 1992) began to move toward a complex textural standpoint - using flowchart modeling approach to capture processes involved with significant business decisions that have high emotive connotations and major implications. Loewenstein (1996) began to move in this direction by incorporating concept of visceral influences on business decision behaviour (Cooksey; 2000). However, these stand points remained linear in conception, relatively static in focus, and highly axiomatic and anchored in a limited set of quantitative variables related in a series of simplistic equations.

General systems theory (Churchman; 1971 and Carson; 1988), applied to managerial decision - making, permits one to differentiate between positive and negative feedback. Negative feedback emerges from comparison of system's goals to system's current position, and, if a discrepancy exists, actions are taken to close the gap. Negative system feedback seeks system equilibrium or stability by dampening variability (minimizing prediction errors). Thus, one form of adaptation in managerial decision - making consists of correcting perceived performance gaps (Cooksey; 2000). Positive system feedback emerges from realisation that focus of business decision may in fact not be correct focus and seeks to create discontinuous shift in system orientation to new forms of business decision behaviour. Positive system feedback thus seeks to create instability by encouraging variation in pursuit of new ways of attaining goals or of new goals themselves. Gates and Cooksey (1998) argued that these concepts are closely related to Argyris's (1990) concepts of single loop learning (emphasis on negative system feedback) and double loop learning (emphasis on both positive and negative system feedback). Consideration of both positive and negative system feedback necessarily invokes importance of time dimension in understanding dynamic nature of complex business decision processes (Cooksey; 2000).

Recently, nonlinear system dynamics has emerged as a way of conceptualizing systems that exhibit strong tendencies toward non - equilibrium. Such systems are characterised by sensitivity to initial conditions, problems in long - term system predictability, bounded instability and periodic excursions into chaotic behaviour (Cooksey and Gates; 1995). This chaotic state of behaviour is stimulated if amount of negative dampening feedback in system is exceeded by amount of positive destabilizing feedback. Result of complex intermixing of positive and negative system feedback is

fundamentally unpredictable behaviour at level of manager manager (Gregersen and Sailer; 1993 and Guastello; 1995). Hitherto that is precisely what contributes to overall texture of managerial decision - making. Because dynamic systems are generally nonlinear, there are no simple pathways through them to some end state or outcome (Cooksey; 2000). Changes in input at one point in business decision process or context, even if minute, may cause huge changes in business decision outcomes. This is a pattern characteristic of sensitivity to initial conditions. Business decision system dynamics may be made even more complex if character of information on which business decision processes act is 'fuzzy' rather than precise in nature (Kosko; 1993).

A reasonable understanding of managerial condition, as it might be brought to bear on managerial decision - making, has been achieved through multiplicity of disciplines, including biology (evolutionary influences and motivational drives), physiology and neurophysiology (emotional response and response mechanisms), cognitive psychology (cognitive complexity), personality psychology (business decision styles, values, and beliefs, achievement motivation and self - efficacy, risk - taking propensity, introversion and extroversion, motivational needs and locus of control), social psychology, organisational psychology, ergonomics (managerial limits and tolerances, information demands) and anthropology (culture, rituals, norms). Epstein (1994), Hammond (1996), Janis (1989), Johnson (1995), Loewenstein (1996) and others has begun to reinforce importance of tracking factors associated with managerial condition. Thus, any new stand point needs to incorporate constraining impacts that managerial condition has on business decision processes unfolding in natural context (Cooksey; 2000).

Conversely, optimal behaviour may emerge when repeated business decisions are made in stationary environments, such as attempt to detect visual stimulus embedded. In terms of computational framework outlined above, during judgments transfer function becomes aligned so that all features fall in linear portion of sigmoid, where inputs are transduced without loss and business decisions are optimal (Summerfield; 2015). Efficient coding is the best strategy in a rapidly - changing, unpredictable world in which optimal inference over all possible eventualities is computationally intractable. Clearly, researchers are just beginning to understand neural circuits that underlie brain's ability to link sensory interpretations with appropriate emotional options. While there is more to cognition than making business decisions about simple sensory stimuli, researchers expect principles

gleaned from these experiments to generalise activities in which researchers plan and choose behaviours from limited repertoire based on information sensed (Shalden;1998).

Pre - Frontal Cortex And Somatic Markers

By far, most studies in cognitive neuroscience have studied how brain responds to experimental events. These studies have revealed how information processing in brain is determined by external input. However, brain is not just a passive receiver of information. It continuously generates its own internal processes, and any input from outside interacts with this spontaneous internal context (Berlin School of Mind and Brain; 2015). Currently, manager is increasingly expected to make business decisions based on paradigms that depart from traditional rationality and information processing models. This is particularly so under crisis conditions, where there is little time and information available for choice consideration. While management literature has recently seen more empirical and theoretical support for intuition and tacit knowledge in business decision process, role of emotion has not played prominent role. This review advances business decision theory by proposing a conceptual model of managerial decision -making that underscores role of emotions in intuitive business decision process under crisis conditions.

Prefrontal Cortex

Cerebral cortex is perhaps a crowning achievement of evolution. It provides biological substrate for managerial cognitive capacity and is, arguably, region of brain that distinguishes one from other. Considering that massive expansion of cortical surface originates during development, understanding cellular and molecular mechanisms regulating cell number and diversity, migration and circuit assembly is critical to shed light into this process. Pre - frontal cortex (PFC) plays critical role in generation and regulation of emotion. Lateral prefrontal cortex is critically involved in broad aspects of managerial emotional control. Early studies emphasized its role in short-term retention of information retrieved from cortical association areas and in inhibition of pre - potent responses. Recent studies of humans have revealed role of this area in more general aspects of emotional planning. Novel findings of neuronal activity have specified how neurons in this area take part in selective attention for action and in selecting intended action. Furthermore, involvement of lateral prefrontal cortex in implementation of emotional rules and in setting multiple emotional goals has been discovered. Recent studies have begun to

reveal neuronal mechanisms for strategic emotional planning and for development of knowledge that enables planning of macrostructures of event-action sequences at conceptual level.

Neuronal recordings (Rustichini1; 2015) indicate that key aspects of managerial decisions take place in orbitofrontal cortex (OFC). Previous work identified three groups of neurons encoding the offer value, chosen value and identity of chosen good. An open question is whether and how business decisions could emerge from a neural circuit formed by these three populations. (Wang; 2002 and 2006). Domain of managerial decisions is significantly broader than that for which the model was originally designed, yet model performs remarkably well. Input and output nodes of network were naturally mapped onto two groups of cells in OFC. Surprisingly, activity of interneurons in network closely resembled that of third group of cells, namely, chosen value cells. Model reproduced several phenomena related to neuronal origins of choice variability. It generated testable predictions on the excitatory/inhibitory nature of different neuronal populations and on their connectivity. Some aspects of empirical data were not reproduced, but simple extensions of model could overcome these limitations. These results render biologically credible model for neuronal mechanisms of managerial decisions. They demonstrate that choices could emerge from activity of cells in OFC, suggesting that chosen value cells directly participate in business decision process. Importantly, Wang's model provides a platform to investigate implications of neuroscience results for managerial theory.

Dixon (2017) states that researchers lack integrative framework for understanding how different emotion-related functions are organised across the entire expanse of PFC, as prior reviews have generally focused on specific emotional processes (business decision - making) or specific anatomical regions (orbitofrontal cortex). Additionally, psychological theories and neuroscientific investigations have proceeded largely independently because of the lack of a common framework. Author provides comprehensive review of functional neuroimaging, electrophysiological, lesion and structural connectivity studies on emotion-related functions of sub regions spanning the entire PFC. Author introduces appraisal - by - content model, which provides new framework for integrating diverse range of empirical findings. Within this framework, appraisal serves as unifying principle for understanding PFC's role in emotion, while relative content - specialization serves as differentiating principle for understanding role of each sub region. A synthesis of data from affective,

social, and cognitive neuroscience studies suggests that different PFC sub regions are preferentially involved in assigning value to specific types of inputs: exteroceptive sensations, episodic memories and imagined future events, viscera - sensory signals, viscera - motor signals, actions, others' mental states (intentions), self - related information and ongoing emotions. Author discusses implications of this integrative framework for understanding emotion regulation, value - based business decision - making, emotional salience, and refining theoretical models of emotion and provides unified understanding of how emotional processes are organised across PFC sub regions and generates new hypotheses about mechanisms underlying adaptive and maladaptive emotional functioning.

Prefrontal Cortex is the cerebral cortex that covers front part of frontal lobe. This brain region has been implicated in planning complex cognitive behaviour and business decision. Typical term for functions carried out by prefrontal cortex area is 'managerial function'. This relates to abilities to differentiate among conflicting thoughts, future consequences of current activities, prediction of outcomes, expectation and 'control' (ability to suppress urges that, if not suppressed, could lead to socially unacceptable outcomes). There are three possible ways to define prefrontal cortex: as granular frontal cortex, as projection zone of the medial dorsal nucleus of thalamus and as that part of frontal cortex whose electrical stimulation does not evoke movements. Prefrontal cortex is of significant importance when top - down processing is needed. Top - down processing by definition is when behaviour is guided by internal states or intentions. Prefrontal Cortex is critical in situations when mapping between sensory inputs, thoughts and actions either are weakly established relative to other existing ones or are rapidly changing' (Source; Wikipedia).

Cognitive theory of mind represents ability of managers to appreciate beliefs and assumptions of other managers, similar to perspective taking. Shazia et. al. (2008) in a study opines that development pattern of frontal lobes involve hierarchical, dynamic and multistage process. Anterior part of frontal lobe, referred as 'pre'- frontal lobe, has been simultaneously referred as 'frontal granular cortex' and 'frontal association cortex.' Prefrontal Cortex occupies anterior most portion of frontal lobe on its medial, lateral and orbital surfaces. Its relative size reaches maximum where it constitutes 30% of cerebral mantle. Prefrontal Cortex occupies one - third of entire cerebral cortex. Prefrontal Cortex is one last cortical region to undergo full myelination. Prefrontal Cortex refers

to paralimbic and heteromodal (site for integration of inputs from more than one sensory modality) components of frontal lobes. Leonardo Bianchi (Bianchi; 1895) opines that frontal lobes are seat of coordination and fusion of incoming and outgoing products of the several sensory and motor areas of cortex [to sum up into series products of sensorimotor regions, as well as emotive states which accompany all perceptions, fusion of which constitutes psychological tone of manager.

Koechlin (2006), in a study on architecture of central managerial functions in prefrontal cortex states that prefrontal cortex subserves managerial control, i.e. ability to select actions and organise behaviour in relation to internal drives and subjective preferences, ranging from simplest behaviours to complex ones. Whether simple or complex, business decisions to act emerge from combination of preferences, drives and choices. Empirical studies suggest that broadly speaking, preferences, drives and choices are respectively processed in ventral, medial and lateral sector of frontal lobes. The lateral sector, especially portion lying anterior to premotor cortex, lateral prefrontal cortex, is a region involved in action selection, when action choices are context - dependent, referred as cognitive control. Cognitive control is subserved by system of lateral prefrontal regions forming cascade of top - down selection processes operating along caudo-rostral axis from premotor cortex to anterior region of frontal lobes, frontopolar cortex. In this system, premotor cortex is involved in selecting actions in response to stimuli (sensorimotor control), while posterior lateral prefrontal regions are involved in selecting premotor representations (stimulus - response associations) according to immediate context of action, i.e. with respect to contextual signals accompanying stimulus occurrences (contextual control). More anterior prefrontal regions, in turn, are involved in selecting posterior prefrontal representations according to the temporal / emotional episode, i.e. with respect to occurrence of past events (episodic control). Finally, frontopolar regions are involved in re - instantiating in anterior prefrontal regions a previously suspended emotional episode upon completion of ongoing one (branching control). In this system, anterior / higher regions are engaged in order to alter or disambiguate action selection in posterior / lower regions on basis of temporally more distant information. Thus, as confirmed by experimental results, cognitive control is organised from posterior to polar prefrontal regions according to temporal rather hierarchical structure of representations involved in action selection.

Managerial function is considered a product of coordinated operation of various processes to ac-

complish a particular goal in a flexible manner. Mechanism or system responsible for coordinated operation of various processes is called managerial control. Impairments caused by damage to prefrontal cortex are called 'dysmanagerial syndromes' (Funahashi; 2000). Consequently, prefrontal cortex is considered to play significant role in managerial control. Prefrontal participation to managerial control can be partly explained by working memory that includes mechanisms for temporary active storage of information and processing stored information. For prefrontal cortex to exert managerial control, neuronal mechanisms for temporary storage of information and dynamic and flexible interactions among them are necessary. In this paper, author presents presence of dynamic and flexible changes in strength of functional interaction and extensive functional interactions among temporal information-storage processes in prefrontal cortex. In addition, recent imaging studies show dynamic changes in functional connectivity between prefrontal cortexes, other cortical and subcortical structures depending upon characteristics or the temporal context of task. These observations indicate that examination of dynamic and flexible modulation in neuronal interaction among prefrontal neurons as well as between prefrontal cortex and other cortical and subcortical areas is important for explaining how prefrontal cortex exerts managerial control (Funahashi; 2000).

Swami (2013), in a paper titled Managerial Functions and Business decision - Making: A Managerial Review provides brief idea about managerial functions. The general components of managerial functions have been identified as: working memory and recall; activation, arousal, and effort; controlling emotions; internalising language; taking issue apart, analysing pieces, reconstituting and organising pieces into new ideas; shifting, inhibiting; organising / planning ahead and monitoring. Then, some pertinent definitions and theories of business decision - making are discussed. Specifically, the following theories of business decision - making have been explained: (i) subjective expected utility (SEU) theory (ii) complex business decisions: multi - attribute utility theory (MAUT) and (iii) prospect theory. Author provides brief overview of cognitive biases, systematic errors and use of heuristics in business decision. Author discusses two heuristics, namely, representativeness heuristic and availability heuristic. Reference framework by Schoemaker and Russo (1993), namely, pyramid of business decision approaches, has been referred by enlisting four approaches: intuition, rules, importance weighting and value analysis. To illustrate use of heuristics, author discusses complex and realistic case study with specific observations in (i) unconscious business

decision (ii) multiple criteria (iii) optimists vs. pessimists and (iv) group business decision.

Yarkoni (2005), in a study on prefrontal brain activity predicts temporally extended business decision behaviour states that although functional neuroimaging studies of business decision processes are increasingly common, most research has relied on passive tasks that generate little manager variability. Relatively little attention has been paid to ability of brain activity to predict overt behaviour. Using functional magnetic resonance imaging (fMRI), author investigates neural mechanisms underlying behaviour during dynamic business decision task that required subjects to select smaller, short-term monetary payoffs in order to receive larger, long-term gains. The number of trials over which long - term gains accrued was manipulated experimentally. Event - related neural activity in right lateral prefrontal cortex, a region associated with high-level cognitive processing, selectively predicted choice behaviour in both conditions, whereas insular cortex responded to fluctuations in amount of reward but did not predict choice behaviour. These results demonstrate utility of functional neuroimaging approach in emotional psychology, showing that (a) highly circumscribed brain regions are capable of predicting complex choice behaviour, and (b) fMRI has ability to dissociate contributions of different neural mechanisms to particular emotional tasks.

Business decision is of general interest to emerging field of cognitive neuroscience, as it draws upon areas of study that have traditionally interested this area of neuroscience. Neural basis of business decision - making has been an elusive concept largely due to sub processes associated with it. Recent efforts (Krawczyk; 2001) involving neuroimaging, neuropsychological studies, and animal work indicate that prefrontal cortex plays central role in several of these sub processes. Frontal lobes are involved in tasks ranging from making binary choices to making multi-attribute business decisions that require explicit deliberation and integration of diverse sources of information. In categorising different aspects of business decision - making, a division of prefrontal cortex into three primary regions is proposed. Orbitofrontal and ventromedial areas are relevant to deciding based on reward values and contribute affective information regarding business decision attributes and options. Dorsolateral prefrontal cortex is critical in making business decisions that call for consideration of multiple sources of information and recruit separable areas when making well defined vs. poorly defined business decisions. Anterior and ventral cingulate cortex appears especially relevant in sorting among conflicting options, as well as

signaling outcome-relevant information. This is broadly relevant to cognitive neuroscience as a discipline, as it generally comprises several aspects of cognition and may involve numerous brain regions depending on the situation. Review concludes with a summary of how these regions may interact in deciding and possible future research directions for the field.

Somatic Markers

Somatic marker hypothesis originates with Walle Nauta (1971). The author states that normal individual decides upon particular course of action by a thought process in which larger or smaller number of strategic alternatives is compared. It could be suggested- admittedly on introspective grounds; that comparison in final analysis is one between affective responses evoked by each of various alternatives. If this were indeed the case, it would be readily understandable that loss of the frontal cortex as a major mediator of information exchange between cerebral cortex and limbic system is followed not only by impairment of strategic choice making, but by tendency of projected or current action systems to 'fade out' or become over-ridden by interfering influences.'

Intuition focuses mind on single emotional objective out of trillions of options. Emotions are not visceral responses. Emotional behaviour persists even when the viscera is isolated. Nerve impulses do trigger emotions. Emotions trigger neurochemical events and physiological responses, which modify behaviours. Contemporary business decision research accepts the idea that emotions play a significant role in business decision . When managers make business decisions, they must assess incentive value of choices available to them, using cognitive and emotional processes. When the managers face complex and conflicting choices, they may be unable to decide using only cognitive processes, which may become overloaded. Emotions, consequently, are hypothesized to guide business decision. 'Somatic markers' are feelings in the body that are associated with emotions that strongly influence subsequent decision. Within brain, somatic markers are thought to be processed in the ventromedial prefrontal cortex (VMPFC) and amygdala. Somatic marker hypothesis proposes that emotions play critical role in ability to make fast, rational business decisions in complex and uncertain situations.

A manager makes swift business decisions when they are in a situation where they face uncertainty about whether their business decisions will lead to benefit or harm. Somatic marker hypothesis attempts to explain how business decisions are

made in face of uncertain outcome. This hypothesis' central theological affirmation is that business decisions are made on neurobiological level and emotions are fundamental aide when business decisions are made. This theory claims emotions contribute when a manager has to make a swift business decision depending on circumstances; bodily states, which arise during deliberation of future consequences and that mark different options of behaviour as having potential to be either advantageous or disadvantageous. This process involves interplay between neural systems that trigger emotional bodily states and neural systems that are map of these emotions or bodily states (Carter; 2004).

Somatic marker hypothesis, formulated by Damasio, proposes that emotional processes guide (or bias) behaviour, particularly business decision - making. Damasio (1996) states that somatic marker hypothesis is relevant to understanding of processes of reasoning and business decision - making. Ventromedial sector of prefrontal cortices is critical to operations postulated, but hypothesis does not necessarily apply to prefrontal cortex as a whole and should not be construed as an attempt to unify frontal lobe functions under a single mechanism. Key idea is that 'marker' signals influence processes of response to stimuli, at multiple levels of operation, some of which occur overtly (consciously, 'in mind') and some covertly (non - consciously, in a non - minded manner). Marker signals arise in bioregulatory processes, including those that express themselves in emotions and feelings, but are not necessarily confined to those alone. This is the reason why markers are termed somatic: they relate to body-state structure and regulation even when they do not arise in the body proper but rather in brain's representation of body. Illustrations of covert action of 'marker' signals are indeliberate inhibition of a response learned previously, introduction of bias in selection of aversive or appetitive mode of behaviour, or in deliberate evaluation of varied option-outcome scenarios. Instances of overt action include conscious 'qualifying' of certain option-outcome scenarios as dangerous or advantageous. Hypothesis rejects attempts to limit reasoning and business decision - making to mechanisms relying, in an exclusive and unrelated manner, on either conditioning alone or cognition alone.

However, why is any of this important? Why take the time to explain process of how emotion might be acted on by the body? Because the main point of this long-winded jaunt through neuroscience leads to business decision-making. Emotional body states can assist in selection of particular answer, in narrowing down of possible choices,

and in sifting through information that may negatively impact survival. After all, 'old brain' is still wired through evolutionary genetics to prioritise survival and safety over all other drives and emotional processes (Damasio, 1994). Damasio suggests that ventromedial prefrontal cortex (VMPFC) sends somatic markers, simulated body signals, which 'bias thoughts and business decisions of managers.' Somatic marker hypothesis includes those structures into its comprehensive account of both choice and valuation, without invoking utility formalism (Reimann and Bechara; 2010). According to the hypothesis, two distinct pathways reactivate somatic marker responses. In the first pathway, emotion can be evoked by changes in the body that are projected to the brain ('body loop'). In the second, cognitive representations of emotions (imagining an unpleasant situation 'as-if' you were in that particular situation) can be activated in brain without being directly elicited by sensory stimulus ('as-if body loop'). Thus, brain can anticipate expected bodily changes, which allows manager to respond faster to external stimuli without waiting for event to occur. Amygdala and VMPFC (subregion of orbitomedial prefrontal cortex or OMPFC) are essential components of this hypothesized mechanism (Trillingsgaard ; 2016). Hypothesis suggests that 'somatic markers' may provide 'variable values' to measure benefits of complex and uncertain choices. According to Comsides and Tooby (2016), 'Mechanisms involved in hierarchically ranking goals or calibrating other kinds of motivational and reward systems should be emotion dependent.' Nevertheless, signals of hierarchically increasing values can provide primitive basis for a choice by system.

Somatic marker hypothesis provides systems-level neuroanatomical and cognitive framework for business decision and influence on it by emotion. The key idea of this hypothesis is that business decision is a process influenced by marker signals that arise in bioregulatory processes, including those that express themselves in emotions and feelings. This influence can occur at multiple levels of operation, some of which occur consciously and some of which occur non-consciously. Here, the authors review studies that confirm various predictions from the hypothesis. Orbitofrontal cortex represents one critical structure in a neural system sub serving business decision. Business decision is not mediated by orbitofrontal cortex alone, but arises from large-scale systems that include other cortical and subcortical components. Such structures include amygdala, somatosensory / insular cortices and peripheral nervous system. Here, authors focus on role of orbitofrontal cortex in business decision and emotional processing and relationship between emotion, business decision

and other cognitive functions of frontal lobe (Bechara; 2000).

Loewenstein, ET al. (2001) suggests role of 'anticipatory' and 'anticipated' emotions in business decision processes. According to them, 'anticipatory emotions are immediate visceral reactions' like fear, anxiety, dread about uncertainties, often felt during business decision whereas 'anticipated emotions' such as disappointment or regret are typically 'not experienced in the immediate present but are expected to be experienced as a result of a business decision.' According to Bagozzi, et al. (2003) anticipated emotions plays an important role to determine the actions of the business decision makers, when dealing with a judgement, like what to choose and why choose it. Study by Isen and Shalcker (1982) showed how one's emotion affects cognitive process. Authors concluded that 'good mood provides access to positive associations in memory and that these weigh in the evaluation'. The study stated that one's mood strongly affects business decisions especially on ambiguous objects which could be either positive or negative (Isen and Shalcker 1982). According to Tirapu-Ustárrroz, et al. (2001) when it comes to executive or business decision, we assume that decides has knowledge of situation requiring business decision about options of action and immediate and future consequences each of these options. In this sense, somatic marker force attention to consequences that may lead a particular action, functioning as automatic alarm signal to inadequacy of any business decision. This signal emotional, can lead to proximately reject a course of action, which would lead to supplementary substitutions. Somatic markers intersect with executive functions in field of discussion, since they are primarily in making business decisions and highlight some other options (Rodrigo; 2012).

Despite debate, somatic marker framework is still providing unique neuroanatomical and cognitive framework that helps explain role of emotion in business decision. According to Peter Walla (2010), this is where it usually gets difficult to track down only one or the other by using traditional methods. Nevertheless, it is presumed before that point arrives both functions provide separate contributions to information processing and it must be possible to define them separately. Cognition-related aspects may be defined easier by traditional approaches because cognition is more tightly linked with information processing. On the other hand, emotion is rather vague and abstract and consequently difficult to describe. There might even be a hemispheric difference separating these two major functions. Cognition as an evaluation may be processed predominantly by left hemi-

sphere while emotion is processed by right hemisphere.

Somatic marker gets force attention to negative outcome that conduct a particular action, and works as alarm signal Automatic says attention to danger that lays ahead if you choose the option that leads to this. Signal can lead to reject, immediately, course of action, which will choose between alternatives. Idea of somatic marker is compatible with notion that effective personal behaviour requires that managers form 'Theories' right of own mind and minds of others. These theories can predict what theories are forming others our own mind (Rolls; 1999). The detail and accuracy of these predictions are, essential as managers' face a critical business decision in a situation social. This leaves open possibility that markers Somatic influence attention and working memory within own regulator. In other words, in normal managers somatic markers that arise from activation of contingency amplify specific attention across the system cognitive (Lambie; 2002).

Loewenstein and Lerner (2003) construe emotions according to their place along the time course of a business decision process, beginning with deliberation phase leading to choice, then implementing choice, and, eventually, experiencing outcomes. They distinguish between anticipated emotions and immediate emotions, with immediate emotions further classified into incidental and anticipatory emotions. Anticipated emotions are beliefs about one's future emotional states that might ensue when outcomes are obtained. Immediate emotions, in contrast, are actually experienced when making a business decision, thereby exerting effect on mental processes involved in making a choice (Kahneman; 2000). Immediate emotions come in two variants, either as incidental emotions caused by factors that are not related to business decision problem at hand, and as anticipatory or integral emotions, which are caused by business decision problem itself. There is ample evidence that these kinds of emotion frequently do influence judgments and choices managers make. Lerner and Keltner (2000) demonstrated the effects of incidental fear and anger on risk judgments. Loewenstein (1996), Zeelenberg, van Dijk, Manstead and Van Der Pligt (2000), has examined influence of immediate anticipatory emotions in intertemporal choice.

Insights of neuroscientific and psychological research, over two decades, have provided new understanding of role that emotional associations play in business decision and judgment. For example, exposure effect provides added support to common rhetorical techniques and raises intriguing

questions regarding influence of such effects on interpersonal relations. It is of critical importance to frame issues in such a manner as to provide clear contrast between options along variable that has emotional association. Depending on context, use of proportions vs. straight numbers vs. narratives can have effect on preferences and biases toward specific business decisions. Finally, it is important to remember that, despite these generalisations, negotiation strategies must be tailored to fit both situation and participants. While some applications of this research corroborate existing practices in field of negotiations, it is anticipated that past and future studies in this area will to assist practitioners who wish to more consistently apply these principles to strategic advantage.

Emotion research is still in its infancy. In terms of Kuhn's (1962) approach to scientific revolutions, it has yet to become 'normal science' with established paradigms. It instead features sparring theories, each trying to represent true nature of emotion. Even the question posed in William James' (1884) 'What is an emotion?' sparks debate (Keltner and Lerner; 2010 and Russell and Barrett; 1999). It is not surprising that within managerial decision literature, specifically, researchers have labeled variety of mental states as 'emotional': from fleeting, momentary reactions (Todorov et al; 2007) to protracted, durable moods (Lerner and Keltner; 2001); from states characterised solely by subjective feelings to those characterised by complex coordination of physiological, hormonal and expressive activity (Bechara et al; 1997, Chapman et al; 2009 and Kassam et al; 2009) and from evaluations that involve simple positive and negative associations to those that involve more complex affective relationships (Loewenstein and Lerner; 2003). Although a full understanding of these relationships is not needed to study influence of emotion on managerial decision. It is nonetheless useful to mention two theoretical questions that can contextualise this review within current state of emotion research: How are emotion and cognition related? What is the consensual model for universe of emotions (discrete versus dimensional)?

Research Gaps and Open Questions Identified

The world we live in is interconnected on all possible level. Complexity science is application of methods and concepts that take into account heterogeneity and interaction between actors, network structure of actors and/or data, and potentially chaotic behaviour of dynamic systems. As advanced economies come to end of process of industrialisation and with rise of information technology, scholarship is witnessing birth of a new

type of post - industrial spectrum, it is built on services, fueled by information and knowledge and it is increasingly integrated through global financial and supply chain networks. These huge changes in deep architecture go far beyond paradigm and are necessitating a re-imagination of decision theory. General equilibrium models that were derived from classical physics were mathematized during 20th century, these models give a picture of isolated, purely rational individuals, optimizing over a well-defined set of preferences out of which we get a macro level general equilibrium in a somewhat static and timeless economy.

A paradigm fitted well with industrial age mechanization. However, limitations of general equilibrium theory are becoming apparent as we build new models, models to individual agents that have bounded rationality, driven by diversity of motives they are interconnected and interdependent. In addition, it is out of these nonlinear interactions we get emergence of institutions as network structures that are far-from-equilibrium that is constantly changing from internal drivers as it develops over time through an evolutionary process. Complexity theory through such approaches as agent-based modeling offers an approach to understanding emotional economics by allowing for specific emotional responses to be assigned to agents who interact within this context, even without full rationality (Rosser; 2015).

Complexity economics extends and complements traditional economics in situations where the influence of the above-mentioned factors impairs the explanatory power of other approaches. Complexity economics is a new and emerging field and is still underrepresented in the economics curriculum. As a field, complexity economics is related to evolutionary economics, control theory and chaos theory. It is an interdisciplinary approach to economic problems, which makes use of a plethora of methods that aim to account for details that are disregarded in more traditional approaches. The simple models that are so fundamental to decision science cannot capture the complex processes that make up economics. By using methods including traditional mathematical / analytical models, traditional econometrics, optimization algorithms, object oriented programming and simulations, complexity economics accounts for network effects, interconnectedness, positive and negative feedback and many other effects.

Increasing competition, globalisation, technological changes, economic upheavals, political uncertainty, changing workforce demographics and other factors are forcing organisations to adopt complexity of business decision-making mech-

anism. Many organisations are currently operating with tired, outdated business decision-making models they often do not know about it. Why we cannot change the business decision apparatus in organisations? Modern neurobiological studies of business decision-making took off around the turn of this century. Potential for cognitive neuroscience to shed light on business decision behaviour is acknowledged. Developments in neuroscience, through 21st Century, provide new understanding of human brain and behaviour that is of importance and application in business decision dynamics. Complex human cognition, such as business decision-making, is reflected in dynamic spatiotemporal activity in the brain. Study of brain and its processes is starting to provide underlying insights that can be applied in real - world and enhance effectiveness of human business decision-making actions and interactions. In magnitude, there is a historical shift beginning in understanding human business decision behaviour.

As organisational species, nature defines what makes us human, what makes us conscious or what gave us brains. Recognising significance of business decisions has led to research on effects of individual characteristics, attention focus, mental frames and other predispositions on performance. Extant research provides evidence that individual's cognitive abilities and mental representations affect innovativeness in business decision-making. Consequence of a diffused and disjointed approach is misconception of essence of organisational business decision. This leads to lack of appreciation of what management business decisions are, who makes them and where they are executed? How do organisations outperform rivals? What are the foundations of competitive advantage? How does business decision identity form on individual, team and organisational level? How do stability and change relate to business decision - identity? What alternative identities and identification targets play a role in business decision - phenomena? As a new field, organisational - brain sciences probe neural underpinnings of business decision - behaviour that has generated provocative and perplexing data. Many organisations are starting to apply the understanding of brain to promote dynamism in pursuit of optimal business decisions. Simulation is a powerful tool that provides important insights about relationship structure-function of brain. Nonetheless, as it is necessary to simplify brain structure and dynamics, scope of findings has limitations (Satpathy, et.al. 2017).

Common misconception is that business decisions are made in isolation: gather information, explore alternatives and make a business decision.

One reason for the gap between the two approaches is the complexity of the interactions involved. The fact is business decisions are made in context of other business decisions. Metaphor used is that of a 'stream'. There is a 'stream of business decisions' surrounding any given business decision. Many business decisions made earlier lead to this business decision. Many other business decisions follow. Most business decisions involve a business decision from pre - selected alternatives, made available from universe of alternatives by previous business decisions. Previous business decisions 'activate' or 'make operable' certain alternatives and 'deactivate' or 'make inoperable' others. Some are 'trapped' by constraining nature of business decision-making to cause a loss of freedom. However, it creates new freedom, business decisions and possibilities. Making a business decision is liberating and constraining. Business decision left unmade often result in business decision by default or business decision being made. Every business decision affects business decision stream and collections of alternatives immediately and in future.

In social and emotional sciences as a whole, we use probability models a lot. For example, we ask, what is the probability that a person will act a certain way or make a certain business decision? Most business decisions are made under conditions of 'risk' defined as uncertainty about possible outcomes when probability is identified. When facilitating business decisions in which some performance evaluations are uncertain, a business decision must be taken about how this uncertainty is to be modeled. This involves, in part, choosing an uncertainty format {a way of representing the possible outcomes that may occur. Utility maximisation explains that humans are rational and assess options based on expected utility gained from each. Research uncovers range of anomalies and common patterns of managerial behaviour inconsistent with code of utility maximisation. Daniel and Tversky proposed prospect model to encompass these observations and offer alternative model. There seem to be multiple brain areas involved in dealing with situations of uncertainty. In tasks requiring predictions, with degree of uncertainty, there is increase in activity in brain. Prefrontal Cortex is generally involved in understanding. These areas determine best course of action when not all relevant information is available. In situations that involve 'known risk' rather than uncertainty, insular cortex is highly active to simulate potential negative consequences. Neurotransmitter dopamine (may) transmit information about uncertainty throughout cortex. Dopaminergic neurons become active after unexpected reward occurs. Dopamine is a modulatory neurotransmitter that is produced by regions in the midbrain. It is

transmitted to a set of cortical and subcortical regions (Cooper, Bloom and Roth; 2002). Trepel, Fox and Poldrack (2005) state that dopaminergic system appears to be a primary substrate for representation of business decision utility. Specifically, increased firing of dopamine neurons has been documented when one is faced with unexpected rewards and in response to stimuli that predict future rewards.

How do we propagate uncertainty about inputs through complex, expensive models to outputs? How do we quantify uncertainty about the model structure itself? Even where we have a good physical description of the structure, there are uncertain elements in the model structure. If available, we can use observations of real system to reduce uncertainty in inputs (inverse modeling) but this introduces complex challenges. There is always a difference between models and real system. Inverse modeling that simply minimises difference between observations and model outputs will tend to 'over fit', yielding misleading results. Thus, inverse modeling needs to estimate both model discrepancy and 'best' input values. The network encourages development of new methodology, both for forward and inverse problem and interactions between business decision managers. Challenges include: the large scale of problems in terms of model and data size, long chains of models and need for 'real-time' methods for business decision. The second theme is concerned with how we use outputs of models to make business decisions. Part of this problem is mathematical. In many circumstances, there is a chain of models leading to making of a business decision. These models will have varying degrees of complexity and some might only involve expert opinion.

Propagating uncertainty through such a chain of models is difficult if we are to avoid uncertainty 'ballooning' because we have not taken the interactions between models into account. The major part of this theme is concerned with psychology and social science. Business decision managers have their own personal internal uncertainty. Different business decision managers faced with same evidence can quite rationally produce different business decisions. How do business decision managers combine this personal uncertainty with mathematically derived uncertainties coming from modeling? What advice can we give to make the process better?

In promising field of managerial decision neuroscience, researchers have recently begun to study neural correlates of valuation signals underlying business decision-making. It is trusted that these efforts are crucial to improving understand-

ing of business decision-making because neuroscientific approaches allow to observe information processes underlying business decision directly in brain that cannot be observed or explained by standard methodologies in psychology / economics. Mathematical formalism of could bring new ways of analysing neural computations involved in representing business decision variables. Results of this could be used to define new theoretical approaches to study of managerial behaviour (Ecole Normale Supérieure, Paris; 2017).

Traditional interpretation has relied on revealed preferences and (sometimes)-on vocal reports to understand desires of individuals and predict actions. NeuroPsycho - economics adds a third method; direct observation of underlying mechanisms leading to choices. Neuroeconomic Model makes one extra step. It uses evidence on brain activity to build models that explain and predict observed behaviours. The advantages are; first, bounded rationality can be modeled in a number of ways. This provides precise guidelines vis-à-vis constraints that should be imposed in business decision-making processes. Second, by explicitly modeling strategic interaction between distinct brain systems, it is possible to provide micro foundations for some aspects of preferences traditionally considered exogenous. Third, theoretical brain models provide new testable implications about functionality of brain systems and their relative importance in different aspects of choice process. Consequently, these methodologies open new directions of experimental investigation in neuroscience that can be of interest for economic business decision-making. Preference - based approach poses axioms on (non-observable) tastes, while choice-based approach defines properties of (observable) choices. As long as rational paradigm holds, consistent choices correspond to rational preferences. When rational paradigm does not hold, there is not such clear mapping. If the focus is on choices and renounces to draw inferences about preferences, models are bound to be limited to situations in which all possible choices are observed. If, instead, researcher draws inferences about preferences from observation of choices, modeling becomes speculative (Satpathy; 2014).

Due to its unbelievable intricacy, brain is an immeasurably stimulating subject. Brain is the last borderline of business decision biology. Understanding how brain learns to compute functions reliably, efficiently and robustly is a fundamental challenge. Most sensory and motor tasks can be described as dynamical systems and could presumably be learned by adjusting connection weights in recurrent biological neural network. Functioning of brain makes what managers are. It brain enables

managers survive as individual and species, react to changing environment, store and retrieve information from past and make business decisions accordingly. What counts as understanding 'managerial brain'? Some problems in neuroscience are nearly solved and solutions for some are times away. Fundamental issue is how brain selectively adapts to important situational changes. While brain needs to adapt to new environments, its architecture has to be protected from modification due to continual barrage of undesirable information. Building models is essential to gain deeper insight into brain mechanisms. Models have advantage that they combine elements of molecular biology, anatomy, physiology, imaging and psychophysics and make quantitative predictions regarding brain activity and behaviour (Seitz ; 2017).

Deciphering brain - environment transactions requires mechanistic understandings of neurobiological processes that implement value-dependent business decision-making. There is a crucial difference between 'thinking about thinking' and actually enhancing brain and mental processes by developing latent potential of each individual. Theoretical accounts posit that human brain accomplishes this through a series of neural computations, in which expected future reward of different business decision options are compared with one another and then option with highest expected value is selected. If human brain is often compared with computer, one aspect is crucially missing. Humans define goals for information processing in computers, whereas goals for biological brains are determined by need for survival in uncertain and competitive environments. How to handle brains behind businesses in age of dramatic change and growing uncertainty? What then are the coherent brain dynamics underlying prediction, control and business decision-making?

Three streams dominate the literature on business decision. Authors in the descriptive stream are concerned with the question:

- How and why do people make business decisions?
- How should managers ideally make business decisions?

Research within the prescriptive stream captures elements of both the normative and the prescriptive stream. Prescriptive research is concerned with the question: How can we help managers making better (not necessarily ideal) business decisions while still taking into account cognitive limitations?.

Business of 'neuromanagerial decision architect' is to understand 'cost' and 'costs of errors' (when Managers decide in a way that is detrimental). Corroboration proposes that coherent business decision depends on preceding precise responsive dispensation. Researches explore neural foundation of business decision certainty and assessment, anticipated efficacy, multiple systems approach and neuroscience. What motivates business decisions we do? How do business decision managers rigid focus impact process and its experience? Research aims at fundamental underpinnings of business decision-making and how they translate into strategic / tactical business decision-making. What role does chronic and induced regulatory focus and form play? Concisely, research aspires to describe neurobiological processes and cognitive mechanisms that underlie management preferences. How does brain generate preferences in the face of variability? Options vary on multiple dimensions. How is business decision encoded in brain? How do we make business decisions when choice options are equally likely or valuable? How does context bias preferences or judgement outside of managers' awareness? From this perspective, understanding neural mechanisms of managerial preference amounts to describing how values are computed and compared.

Conjecture of brain is aptitude to trait mental states; attitude, intents, requirements, pretends comprehension, etc. to appreciate that others have beliefs, desires, intentions and perspectives dissimilar from one's own. Conjecture of brain is a surmise insofar as brain is not directly evident. Having conjecture of brain allow judgment, requirements and intention to others, forecast or elucidate actions and hypothesize intentions. It enables to value that psychological state can be root of, explicate and calculate behaviour of others. Being able to feature mental states as cause of behaviour implies brain as author of representation. Existing deliberations have ancestry in rational debate (Descartes' Second Meditation) as basis for making allowance for discipline of brain dynamics. Familiar divergent approach in philosophical journalism, to conjecture of brain is conjecture-conjecture and simulation - conjecture. Conjecture-theorist envisions absolute conjecture to rationale about others' brains. Conjecture is developed mechanically and instinctively, though instantiated interactions. It is intimately associated perception and ascription that quality mind, actions, effectiveness, properties, realisation and link to corporeal body (brain).

Managerial efficacy is umbrella term for management of cognitive processes. Managerial scheme is a theorised cognitive structure that di-

rects cognitive processes. Prefrontal areas of frontal lobe are necessary but not solely sufficient for hauling out this efficacy. Conventionally, managerial efficacy has been synchronised by prefrontal regions of frontal lobes. It is a matter of unending contest. Frontal and non-frontal regions are essential for integral efficacy. Probably, frontal lobes need to play a part in fundamentally the whole efficacy. 'The problem is, we're not always sure which are the circumstances the older part is good for and which are the ones that our prefrontal cortex is good for. So we live in a funny world in which different parts of our brain are adapted to different types of circumstances, but we don't have a control structure that knows which one would be the most appropriate in any given instance; we're not optimized in that way. And yet, we have to make such business decisions all the time' (Jonathan Cohen; 2010). Managerial system is ideated to be profoundly drawn in handling situations exterior domain of mechanical processes that explain imitation of set behaviours; those that engross business decision, those involve inaccuracy rectification, where response are not well-rehearsed, in principle tricky situations and that necessitate overcoming of tough response (Satpathy; 2015).

Collocation of contemporaneous converses has amplified experiences of paradoxical rigidities, stimulating management actors. What happens in brain or is activated when we deal or are in process of business decision-making? Is neuromanagement of business decision processes relevant for management? Many seek information than required to make a business decision. Information overload is a fact, making Managerial decision making confusing. Although business decision offers options, too many business decisions or features per business decision can cause delay in Managerial decision or make less-than-optimal business decisions. Four pairs of paradoxical needs drive managerial decision cycle: 'Certainty' and 'Uncertainty', 'Individuality' and 'Connectedness'. Certainty provides order. Uncertainty provides growth. Both 'order' and 'growth' are required to complete business decision cycle. This is a paradox. How to process dissimilar inputs and make complicated business decision? Variations on this question have implications. Key involves 'psychological distancing', removing oneself from morass of details surrounding business decision on abstract level. In this state, neuromanagement seeks to explain business decision-making, ability to process alternatives and choose optimal course of action. It studies how behaviour shape understanding of brain and guide models of management. Deciphering such transactions require understanding of neuro processes through neural computations. What are the coherent brain dynamics?

The above leads to formulation of a 'neuro - paradox' (more choices may lead to a poorer business decision or a failure to make a business decision). The realisation for this 'paradox' comes from straightforward observation that there are numerous business decision-making methods (both normative and descriptive) and these methods yield different results when fed with exactly the same business decision problem and data (Wikipedia). Basic question is how actions are assembled into organised arrangements. Theories of sequential behaviour acknowledge that it must rely not only on climatic cues but on internal representation of temporal or task context. It is presumed that such internal representations be organised into strict hierarchy, mirroring hierarchical structure of realistic sequential behaviour. Theorised to be caused by analysis paralysis, goal is to model how brain implements business decision tied to managerial behaviour.

Managerial neuro - business decision arose out of a controversy. By determining, which brain areas are active in which types of business decision processes, neuromanagement researchers understand nature of what seem to be suboptimal and illogical business decisions. While researchers use human subjects, others use specie models where studies are tightly controlled and assumptions tested directly. These processes proceed in a logical manner such that business decision itself is largely independent of context. Neuromanagement converges around emotional deviations from model of human being as homo economicus (rational actor who calculates preferences to maximise satisfaction). Business decision research in neurobusiness decision has been oscillated by homo economicus metaphor with emphasis on normative models and deviances from calculations of those models. In contrast, key representation of cognitive neurobusiness decision conceptualises humans as 'information processors'. Many describe theories similar to those involved in business decision, thereby increasing cross - fertilisation between the dual. Why do humans value present at expense of future? There is contentious debate how to model this tendency at neural level. Should brain be conceptualised as unified business decision-making apparatus? Debate ranges on how to define constraints on human reason with which regulative strategies must contend. Programme tends to combine neural data and managerial emotional evidence derived from experimental protocols. Dissimilar options are translated and compared. Option with largest overall utility value is the one that is chosen. While there has been support for this view, there are situations where assumptions of optimal business decision seem to be violated.

‘Volatility’ and multi - factors determine management and business decision -making approach. Aim is to point out that specific features (uncertainty, limitation of skills and abilities) necessitate search for new approaches that fit new challenges. Managerial element is a multi - faceted system whose aggregate behaviour is determined by incredible number of co - existing interactions that draw analogies. Management ‘agents’ constantly interact for dissimilar purposes. Manager interactions behaviour emerges at aggregate level. Among the elements that contribute to emergence of collective patterns, information exchange is important. However, macroscopic behaviour cannot be reflecting managerial behaviour of a ‘typical’ or ‘average’ manager. Managerial behaviour at collective level may not be deduced, calculated or extrapolated simply from linear aggregation of managerial behaviour.

Why should management business decision be an exception? Number of coordination phenomena exists cut across range of levels, creatures and functions. There is unanimity regarding self-organised nature of brain. Phase synchrony emerges when information is exchanged (Edelman; 2004 and Kelso; 1995). This is knowledge about business decision, effects of alternatives, probability of each alternative and so forth. While substantial information is desirable, testimonial that ‘more information, better’ is not true. In judging quality of business decision, use of information and alternatives, three other considerations come into play: business decision must meet stated objectives. How well do alternatives meet identified goals? Are there negative consequences to alternative that make that business decision less desirable?

Crucial problem of synchronisation dynamics is to identify key variables of coordination and dynamics. Basic forms of coordination emerge because of system’s ability to self-organise when open to information exchange. ‘System consists of organisms and their climate, with full recognition of co-evolution. Along with predictive quantitative modelling, coordination dynamics provides foundation for understanding coordinated managerial behaviour grounded in concepts of self-organisation and tools of nonlinear dynamics tailored to handle informational (Engstrøm ;2006). Advances in brain sciences have revealed self-organised and informational nature of managerial behaviour and cognition (Bressler; 2001). Neumanagement, from this point, could be conceived as coordination dynamics of management business decision-making from unstable to stable cognitive states involving neurons and / or parts of brain (Oullier ;2008). It is rather surprising that such a

perspective has not (yet) been explored by neumanagement researchers in spite of nonlinear features exhibited by both brain and cognitive processes at multiple levels of description (Kelso; 2006).

Some **issues** in managerial decision-making are;

- Managerial decision under risk and ambiguity,
- Preference under conflict: hedonic vs. Utilitarian approaches,
- Preference under conflict: time pressure, preference under conflict,
- Multi attribute managerial management business decision ,
- Inter-temporal preference,
- Construal model, loss aversion and reference-dependence,
- Probability assessments,
- Calibration and overconfidence,
- Optimism,
- Causal reasoning ,
- Perception of randomness,
- Framing effects interpretation and consequences,
- Do feelings precede preference,
- Role of emotions,
- Moral judgments and sacred values, trust and mutuality,
- Fairness, procedural approaches,
- Imprecision and noise,
- Biases: implications, joint vs. distinct modes of evaluation, and
- Innovative directions, topical perspectives and conceivable future developments.

Neoclassical revolution had two profound effects during the second half of 20th Century. It largely revealed how rational utility maximiser would behave and essentially proved that humans could not be viewed as efficient utility maximisers under all conditions. This insight led (Simon; 1997), to conclude that business decision managers could be viewed as rational utility maximisers in only a ‘bounded’ sense. Conditions do occur under which humans behave rationally and irrationally. An outcome has been a growing conviction that business decision-making can be viewed as product of two underlying processes; bounded rational process designated by prescriptive model and empirically irrational process. Goal is to resolve this discrepancy by demonstrating how neuroscientific experiments can be used for developing real theories and models.

When researchers try to study human behaviour using only classical mathematical models of rationality, some aspects of human behaviour do not compute. From the classical point of view, those behaviours seem irrational (Wang; 2015). 'I think that classical economic theory probably describes a good first approximation of some part of our brain. After all, it was invented by some part of our brain. There are times we behave in rough accord with it. When we are thinking about our global goals and we have the luxury to contemplate the relative merits of this versus that, and we're not as pressed by our immediate needs or emotional responses we tend to make rational choices. And that's not to say that those emotional responses don't have optimal functions of their own — but they are not as aligned with standard economic theory' (Jonathan Cohen; 2010). Studies suggest that two processes; rational and irrational, may be instantiated within brain as two distinct mechanisms. Many suggest that irrational behaviour be distinctively attributed to limitations intrinsic to neural architecture. Others suggest that rational behaviour be viewed as product of conscious faculty that transcends biological constraint. While explaining irrational effects, brain, including entire neurophysiological system, takes over gradually in case of familiar mastered tasks and plays equivalent of lightning chess ... all without conscious thinking by mind' (Vernon Smith ; 2003). Mechanical processes of brain itself account for irrationality bounds rational processes of conscious mind. Camerer (2003) suggests that business decision-making be viewed as product of cognitive and affective (or, emotional) system. These two systems co - exist as independent entities within neural architecture because they have dissimilar evolutionary origins. Each of these individual segments can be restricted to discrete functional regions within human brain.

This seems to argue that in order to behave rationally, humans need to evolve unique facility. If this is true then it is both; rational and irrational challenging assumption that aspects of neuromanagerial behaviour involve unique processes. In such a situation, how can we understand dynamic lifecycle of business decision – making? Again, how business decision will be framed, preferences arrived at and commitments to actions made (Fox and Das; 2000)? What are the general functions that underpin and constrain processes that implement such a lifecycle for any kind of cognitive agent, whether the agent is natural or artificial? How does business decision-making fit within cognitive science's strategic objective of a unified model of cognition (Newell; 1990, Anderson; 2007 and Shallice and Cooper; 2011)? How can we apply this understanding to business decision initiating, drawing on insights

into how business decisions are and / or ought to be made to inform design of autonomous cognitive agents and business decision support systems (Fox ;2010)?

New brain imaging technologies have motivated neuromanagerial studies of internal order of mind. We are only at beginning of an enterprise. Its promise suggests a fundamental change in how we think, observe and model business decision in context. Brain absorbs information, recognises and frames problematic situations towards appropriate responses. Business decision-making in neuromanagement is based on complexly interlinked imaging technologies with links to bandwidth of human business decision. Manager often fail to design 'rational' business decisions. Processes by which Managers reach business decisions embody conflicting tenets. Question is how Manager makes business decisions. How are business decisions carried out in brain? Interest is on assumptions, beliefs, habits and tactics that Manager uses to make business decisions. How do parts of brain govern business decision-making, coordinate, face obscurity and engage in strategic simplification while deciding? What happens in brain or is activated? Is study of business decision-making geometry via neuromanagement relevant? What are the limits? How does previous experience alter behaviour? There are unsolved problems in (managerial) cognition. What are the general implications? Managerial cognition plays a role. Sensing is as an important aspect and there is evidence of how evolutionary patterns are shaped by beliefs and attention allocation. How does Manager decide in state of VUCA (Uncertainty, Vulnerability, Complexity and Ambiguity)? In this, neuromanagement seeks to explain business decision-making, ability to process alternatives and choose optimal course of action. It studies how management behaviour shape understanding of brain and guide coherent brain geometry towards business decision-making (Satpathy and Gankar; 2016)?

Managerial assumption has been interested by which Managers reach business decisions. Managerial decisions have been subject of psychological (examining in context of set of needs, preferences and values), **Cognitive** (regarded as continuous process integrated with environment) and **Normative** (scrutiny concerned with logic of business decision-making and rationality). What are the unsolved problems of neuro - managerial decision dynamics? How does a neural circuit accumulate information to gather evidence over time? How is a categorical business decision produced? What is a business decision threshold in neuronal terms? Is there a common mechanism for perceptual business decisions and value-based business decision

behaviour? What is the source of stochasticity in probabilistic business decision-making? Can Bayes-like inference be realised by simple neural mechanisms in brain? Does business decision behaviour generally deviate from Bayes-optimality? This dwells on issues viz. How does Manager decide in state of vacillation? How and where does the brain evaluate reward value and effort (cost) to modulate conduct? How does previous experience alter perception and conduct? What are the genetic and environmental contributions? Key questions include how brain represents value of different preferences and how this information is combined to yield optimal business decisions. Which are the limits for testability in business decision-making experiments? Could we test business decision-making perfectly mimicking real contexts? Is top-down control involved in business decision? Do we have free will and to what extent we have space for preference, if any? How do we know where we are, where we have been and where we are going? What do brain scans really tell us? What are the practical implications (Satpathy and Gankar; 2016) ?

Despite substantial advances, question of how we design and how to design judgments and business decisions through characteristically different techniques. Among the big questions, they are; How do neurons code the emotional weight of our experiences? Do some neurons become active in response to negative experiences while other neurons fire when we experience something favourable? How do neurons code numerical value of various options? Do more or different neurons fire for an option with bigger rewards than that for a lesser reward? How does coding for rewards differ from that of rewards delayed? How do parts of brain govern business decision-making coordinate their activity? What triggers a business decision? Is it cumulative build-up of firing neurons that tip to final business decision? How do we alter business decision-making rules while facing new information that makes those rules obsolete? Some key issues are; what are the constituent processes underlying managerial efficacy task performance? What are managerial efficacy issues? Are different managerial efficacy's uniquely linked to different brain regions? How do changes in brain efficacy contribute to changes in managerial efficacy? Is risk and return related? Can risk be managed? Is it possible to identify risk-prone and risk-averse prospects? Do managers use computer-based business decision aids with risk estimations in business decision problems? What symptoms of managerial efficacy issues find hard to figure out how to get started on a task?

What could we learn about being managerial if we weave psychological sciences, neurosciences, biological sciences, and physical sciences into a single integrated depiction? Can we create a comprehensive model to perceive and influence network of interactions? What is the way to describe this interaction to understand managerial decision dynamics? Basic question is how actions are assembled into organised sequences. Theories acknowledge that it must rely not only on environmental cues but on internal representation of temporal or task context. It is presumed that such representations must be organised into a strict hierarchy, mirroring hierarchical structure of naturalistic sequential behaviour. Based on neuroscience evidence, we model brain as a dual-system organisation subject to asymmetric information, temporal horizon and incentive salience. In business decision-making, purposes must be established, classified and placed in order of importance, substitute actions be developed and be evaluated against all purposes. Substitute that achieves purposes is the tentative business decision evaluated for more possible consequences to prevent adverse consequences. These steps result in an optimal plan. Neural level focuses on basic brain functions and shows how processing demands dictate extensive use of timing-based circuitry (Satpathy and Gankar; 2016).

Human performance has been subject of active research from several perspectives. Neuromanagement explains human business decision-making, ability to process multiple alternatives and choose an optimal course of action. It studies how management behaviour shape understanding of brain and guide models of management via. Neuromanagement science, neuromanagement management, cognitive and organisational psychology. As research in business decision - making behaviour becomes computational, it incorporates approaches from theoretical biology, computer science and mathematics. Neuromanagement adds by using methods in behaviour and neural mechanisms. By using tools from various fields, Neuromanagement management offers an integrative way of understanding business decision. If further proof were needed, neuromanagement provides evidence to explain business decision-making, ability to process multiple alternatives and choose optimal course of action. It studies how management behaviour shape understanding of brain and guide models of neuromanagement.

Deciphering brain - environment transactions requires mechanistic understandings of neuromanagement processes that implement value-dependent business decision-making. There is a crucial dif-

ference between 'thinking about thinking' and actually enhancing brain and mental processes by developing latent potential of each individual. Theoretical accounts posit that human brain accomplishes this through series of neural computations, in which expected future reward of different business decision options are compared with one another and option with highest expected value is selected. If human brain is often compared with a computer, goals for biological brains are determined by need for survival in uncertain and competitive environments. How to handle brains behind businesses in age of dramatic change and growing uncertainty? What then are the coherent brain dynamics underlying prediction, control and business decision-making?

Neuromanagement seeks to ground management theory in neural mechanisms and make neuromanagement predictions. Neuromanagement uses knowledge about brain mechanisms to inform management theory. It opens up the 'Black Box' of brain. The key insight is that brain is composed of multiple systems that interact. Controlled systems ('executive function') interrupt automatic ones. Brain evidence complicates standard assumptions about basic preference and shows emotional activation in strategic interaction. This research problem starts with the premise that basic business decisions can be traced back in structure of macro-scale brain activity, as measured with neuro - imaging apparatus. Such responses involve regions in brain (prefrontal cortex), whose precise function depends upon context (specific task). This 'context-dependency' expresses itself through (induced) specific plasticity of these networks, in parallel to tonic changes in neuro - modulator activity. In turn, reconfiguration of brain networks subtends adaptive behaviour. It is likely that behaviour emerges from interactions that shape dynamics of brain networks. Understanding mechanics of processes from brain activity and neuromanagement measurements pose exciting challenge of processing to brain connectivity.

Questions that need to be answered include; how to choose in tough situations where stakes are high and there are multiple conflicting objectives? How should Managers' plan? How can we deal with risks and uncertainties involved in a business decision? How can we create options that are better than the ones originally available? How can we become better business decision makers? What resources will be invested in business decision - making? What are the potential responses to a particular problem or opportunity? Who will make this business decision? Every prospective action has strengths and weaknesses; how should they be evaluated? How will they decide? Which of the

things that could happen would happen? The business decision has been made. How can we ensure it will be carried out? These are the questions neuromanagement researchers suspect are most crucial for understanding complex human behaviours.

Despite substantial advances, the question of how we make business decisions and judgments continues to pose important challenges for scientific research. Historically, different disciplines have approached this problem using different techniques and assumptions, with few unifying efforts made. Making a managerial decision implies that there are alternative business decisions to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that (1) has the highest probability of success or effectiveness and (2) best fits with our goals, desires, lifestyle, values, and so on. Managerial decision - making is the process of sufficiently reducing uncertainty and doubt about alternatives to allow a reasonable business decision to be made from among them. This definition stresses the information-gathering function of business decision-making. It should be noted here that uncertainty is reduced rather than eliminated. Few business decisions are made with absolute certainty because complete knowledge about all alternatives is seldom possible. Thus, every business decision involves a certain amount of risk. If there is no uncertainty, you do not have a business decision; you have an algorithm--a set of steps or a recipe that is followed to bring about a fixed result.

Emerging neuromanagement science evidence suggests that sound and rational neuromanagement decision making depends on prior accurate emotional processing. Somatic marker hypothesis provides a systems-level neuromanagement anatomical and cognitive framework for neuromanagement decision making and its influence. Key idea is that neuromanagement decision - making is a process influenced by Prefrontal Cortex and Marker Signals. These occur at multiple levels of operation. Some occur consciously and some occur non-consciously. The issues that crop up are; what happens when Managers change minds? What algorithms allow sensorimotor behaviours to be learned? What computational mechanisms allow brain to adapt changing circumstances? How (and where) are value and probability combined in brain and what is the dynamics of this? What neural systems track defined forms of utility? To what extent do utility computations generalize to business decision that is tasks that are more complex? How do systems that focus on immediate business decisions interact?

One reason for a cavern between gathering information, exploring alternatives and making a business decision is the complexity of interactions involved. The fact is, business decisions are made in context of other business decisions. Metaphor used is that of a 'stream'. There is a 'stream of business decisions' surrounding any given business decision. Many business decisions made earlier lead to this business decision. Many other business decisions follow. Most business decisions involve a business decision from pre-selected alternatives, made available from universe of alternatives by previous business decisions. Previous business decisions 'activate' or 'make operable' certain alternatives and 'deactivate' or 'make inoperable' others. Some are 'trapped' by constraining nature of business decision-making to cause a loss of freedom. However, it creates new freedom, business decisions and possibilities. Making a business decision is liberating and constraining. Business decision left unmade often result in business decision by default or business decision being made. Every business decision affects business decision stream and collections of alternatives immediately and in future.

'The essence of the situation is action according to opinion, of greater or less foundation and value, neither entire ignorance nor complete and perfect information, but partial knowledge. If we are to understand the workings of the economic system we must examine the meaning and significance of uncertainty; and to this end some inquiry into the nature and function of knowledge itself is necessary' (Frank H Knight; 1921).

In the social and emotional sciences as a whole, we use probability models a lot. For example, we ask, what is the probability that a person will act a certain way or make a certain business decision? Most business decisions are made under conditions of 'risk' defined as uncertainty about possible outcomes when probability is identified. When facilitating business decisions in which some performance evaluations are uncertain, a business decision must be taken about how this uncertainty is to be modelled. This involves, in part, choosing an uncertainty format {a way of representing the possible outcomes that may occur. Utility maximisation explains that humans are rational and assess options based on expected utility gained from each. Research uncovers range of anomalies and common patterns of managerial behaviour inconsistent with code of utility maximisation. Daniel and Tversky proposed prospect model to encompass these observations and offer alternative model. There seem to be multiple brain areas involved in dealing with situations of uncertainty. In tasks requiring predictions, with degree of uncer-

tainty, there is increase in activity in brain. Prefrontal Cortex is generally involved in understanding. These areas determine best course of action when not all relevant information is available.

In situations that involve 'known risk' rather than uncertainty, insular cortex is highly active to simulate potential negative consequences. Neurotransmitter dopamine (may) transmit information about uncertainty throughout cortex. Dopaminergic neurons become active after unexpected reward occurs. Dopamine is a modulatory neurotransmitter that is produced by regions in the midbrain. It is transmitted to a set of cortical and subcortical regions (Cooper, Bloom and Roth; 2002). Trepel, Fox and Poldrack (2005) state that dopaminergic system appears to be a primary substrate for representation of business decision utility. Specifically, increased firing of dopamine neurons has been documented when one is faced with unexpected rewards and in response to stimuli that predict future rewards.

How do we propagate uncertainty about inputs through complex, expensive models to outputs? How do we quantify uncertainty about the model structure itself? Even where we have a good physical description of the structure, there are uncertain elements in the model structure. If available, we can use observations of real system to reduce uncertainty in inputs (inverse modeling) but this introduces complex challenges. There is always a difference between models and real system. Inverse modeling that simply minimises difference between observations and model outputs will tend to 'over fit', yielding misleading results. Thus, inverse modeling needs to jointly estimate both model discrepancy and 'best' input values. The network encourages development of new methodology, both for forward and inverse problem and interactions between business decision managers. Challenges include: large scale of problems in terms of model and data size, long chains of models and need for 'real-time' methods for business decision. The second theme is concerned with how we use outputs of models to make business decisions. Part of this problem is mathematical. In many circumstances, there is a chain of models leading to making of a business decision. These models will have varying degrees of complexity and some might only involve expert opinion. Propagating uncertainty through such a chain of models is difficult if we are to avoid uncertainty 'ballooning' because we have not taken the interactions between models into account. The major part of this theme is concerned with psychology and social science.

Business decision managers have their own personal internal uncertainty. Different business decision managers faced with same evidence can quite rationally produce different business decisions. How do business decision managers combine this personal uncertainty with mathematically derived uncertainties coming from the modelling? What advice can we give to make the process better?

Business of 'neuromanagement decision architect' is to understand 'cost' and 'costs of errors' (when Managers decide in a way that is detrimental). Corroboration proposes that coherent business decision depends on preceding precise responsive dispensation. Researches explore neural foundation of business decision certainty and assessment, anticipated efficacy, multiple systems approach and neuroscience. What motivates business decisions we do? How do business decision managers rigid focus impact process and its experience? Research aims at fundamental underpinnings of business decision-making and how they translate into strategic / tactical business decision-making. What role does chronic and induced regulatory focus and form play? Concisely, research aspires to describe neuromanagement processes and cognitive mechanisms that underlie management preferences. How does brain generate preferences in the face of variability? Options vary on multiple dimensions. How are business decisions encoded in the brain? How do we make business decisions when the choice options are equally likely or valuable? How does context bias preferences or judgement outside of the business decision-managers' awareness? From this perspective, understanding neural mechanisms of managerial preference amounts to describing how values are computed and compared.

Conjecture of brain is aptitude to trait mental states; attitude, intents, requirements, pretends comprehension, etc. to appreciate that others have beliefs, desires, intentions and perspectives dissimilar from one's own. Conjecture of brain is a surmise insofar as brain is not directly evident. Having conjecture of brain allow judgment, requirements and intention to others, forecast or elucidate actions and hypothesize intentions. It enables to value that psychological state can be root of, explicate and calculate behaviour of others. Being able to feature mental states as cause of behaviour implies brain as author of representation. Existing deliberations have ancestry in rational debate (Descartes' Second Meditation) as basis for making allowance for discipline of brain dynamics. Familiar divergent approach in philosophical journalism, to conjecture of brain is conjecture-conjecture and simulation - conjecture. Conjecture-

theorist envisions absolute conjecture to rationale about others' brains. Conjecture is developed mechanically and instinctively, though instantiated interactions. It is intimately associated perception and ascription that quality mind, actions, effectiveness, properties, realisation and link to corporeal body (brain).

Managerial efficacy is umbrella term for management of cognitive processes. Managerial scheme is a theorised cognitive structure that directs cognitive processes. Prefrontal areas of frontal lobe are necessary but not solely sufficient for hauling out this efficacy. Conventionally, managerial efficacy has been synchronised by prefrontal regions of frontal lobes. It is a matter of unending contest. Frontal and non-frontal regions are essential for integral efficacy. Probably, frontal lobes need to play a part in fundamentally the whole efficacy. 'The problem is, we're not always sure which are the circumstances the older part is good for and which are the ones that our prefrontal cortex is good for. So we live in a funny world in which different parts of our brain are adapted to different types of circumstances, but we don't have a control structure that knows which one would be the most appropriate in any given instance; we're not optimized in that way. And yet, we have to make such business decisions all the time' (Jonathan Cohen; 2010). Managerial system is ideated to be profoundly drawn in handling situations exterior domain of mechanical processes that explain imitation of set behaviours; those that engross business decision, those involve inaccuracy rectification, where response are not well-rehearsed, in principle tricky situations and that necessitate overcoming of tough response (Satpathy; 2015).

Collocation of contemporaneous converses has amplified experiences of paradoxical rigidities, stimulating management actors. What happens in brain or is activated when we deal or are in process of business decision-making? Is neuromanagement of business decision-making processes relevant for management? Many seek information than required to make a business decision. Information overload is a fact, making Managerial decision making confusing. Although business decision offers options, too many business decisions or features per business decision can cause delay in Managerial decision or make less-than-optimal business decisions. Four pairs of paradoxical needs drive managerial decision cycle: 'Certainty' and 'Uncertainty', 'Individuality' and 'Connectedness'. Certainty provides order. Uncertainty provides growth. Both 'order' and 'growth' are required to complete business decision cycle. This is a paradox. How to process dissimilar inputs and make complicated business decision? Variations on this

question have implications. Key involves 'psychological distancing', removing oneself from morass of details surrounding business decision on abstract level. In this state, neuromanagement seeks to explain business decision-making, ability to process alternatives and choose optimal course of action. It studies how behaviour shape understanding of brain and guide models of management. Deciphering such, transactions require understanding of neuro processes through neural computations. What are the coherent brain dynamics? This leads to formulation of a 'neuro - paradox' (more choices may lead to a poorer business decision or a failure to make a business decision). The realisation for this 'paradox' comes from straightforward observation that there are numerous business decision methods (both normative and descriptive) and these methods yield different results when fed with exactly the same business decision problem and data (Wikipedia). Basic question is how actions are assembled into organised arrangements. Theories of sequential behaviour acknowledge that it must rely not only on climatic cues but on internal representation of temporal or task context. It is presumed that such internal representations be organised into strict hierarchy, mirroring hierarchical structure of realistic sequential behaviour. Theorised to be caused by analysis paralysis, goal is to model how brain implements business decision tied to managerial behaviour.

Managerial neuro - business decision arose out of a controversy. By determining, which brain areas are active in which types of business decision processes, neuromanagement researchers understand nature of what seem to be suboptimal and illogical business decisions. While researchers use human subjects, others use specie models where studies are tightly controlled and assumptions tested directly. These processes proceed in a logical manner such that business decision itself is largely independent of context. Neuromanagement converges around emotional deviations from model of human being as homo economicus (rational actor who calculates preferences to maximise satisfaction). Business decision research in neurobusiness decision has been oscillated by *homo economicus* metaphor with emphasis on normative models and deviances from calculations of those models. In contrast, key representation of cognitive neurobusiness decision conceptualises humans as 'information processors'. Many describe theories similar to those involved in business decision, thereby increasing cross - fertilisation between the dual. Why do humans value present at expense of future? There is contentious debate how to model this tendency at neural level. Should brain be conceptualised as unified business decision-making apparatus? Debate ranges on how to define con-

straints on human reason with which regulative strategies must contend. Programme tends to combine neural data and managerial emotional evidence derived from experimental protocols. Dissimilar options are translated and compared. Option with largest overall utility value is the one that is chosen. While there has been support for this view, there are situations where assumptions of optimal business decision seem to be violated.

'Volatility' and multi - factors determine management and business decision -making approach. Aim is to point out that specific features (uncertainty, limitation of skills and abilities) necessitate search for new approaches that fit new challenges. Managerial element is a multi - faceted system whose aggregate behaviour is determined by incredible number of co - existing interactions that draw analogies. Management 'agents' constantly interact for dissimilar purposes. Manager interactions behaviour emerges at aggregate level. Among the elements that contribute to emergence of collective patterns, information exchange is important. However, macroscopic behaviour cannot be reflecting managerial behaviour of a 'typical' or 'average' manager. Managerial behaviour at collective level may not be deduced, calculated or extrapolated simply from linear aggregation of managerial behaviour.

Why should management business decision be an exception? Number of coordination phenomena exists cut across range of levels, creatures and functions. There is unanimity regarding self-organised nature of brain. Phase synchrony emerges when information is exchanged (Edelman; 2004 and Kelso; 1995). This is knowledge about business decision, effects of alternatives, probability of each alternative and so forth. While substantial information is desirable, testimonial that 'more information, better' is not true. In judging quality of business decision, use of information and alternatives, three other considerations come into play: business decision must meet stated objectives. How well do alternatives meet identified goals? Are there negative consequences to alternative that make that business decision less desirable?

Crucial problem of synchronisation dynamics is to identify key variables of coordination and dynamics. Basic forms of coordination emerge because of system's ability to self-organise when open to information exchange. 'System consists of organisms and their climate, with full recognition of co-evolution. Along with predictive quantitative modelling, coordination dynamics provides foundation for understanding coordinated managerial behaviour grounded in concepts of self-organisation and tools of nonlinear dynamics tai-

lored to handle informational (Engstrøm ;2006). Advances in brain sciences have revealed self-organised and informational nature of managerial behaviour and cognition (Bressler; 2001). Neuromanagement, from this point, could be conceived as coordination dynamics of management business decision-making from unstable to stable cognitive states involving neurons and / or parts of brain (Oullier ;2008). It is rather surprising that such a perspective has not (yet) been explored by neuromanagement researchers in spite of nonlinear features exhibited by both brain and cognitive processes at multiple levels of description (Kelso; 2006).

How is managerial decision making processes carried out in brain? Do we interpret research findings when results conflict? Knowing how brain is working explains little about what mind produces; what we think, what we believe and how we craft business decisions. What are the general implications? Neuro techniques permit to look inside brain while it experiences outcomes and crafts business decisions to examine implications. Central argument is that business decision is at staple of Managerial functions and future of any organisation lies on vital business decisions made. Business decision usually involves three steps: recognition of a need, dissatisfaction within oneself (void or need), business decision to change (fill void or need) and conscious dedication to implement the business decision. However, certain critical issues coupled with factors such as uncertainties, multiple objectives, interactive multi - faceted and anxiety make business decision-making process difficult. At times when making a business decision is multi - faceted or interests are at stake, then need for strategic business decision arises.

Neoclassical revolution had two profound effects during the second half of 20th Century. It largely revealed how rational utility maximiser would behave and essentially proved that humans could not be viewed as efficient utility maximisers under all conditions. This insight led (Simon; 1997), to conclude that business decision managers could be viewed as rational utility maximisers in only a 'bounded' sense. Conditions do occur under which humans behave rationally and irrationally. An outcome has been a growing conviction that business decision-making can be viewed as product of two underlying processes; bounded rational process designated by prescriptive model and empirically irrational process. Goal is to resolve this discrepancy by demonstrating how neuroscientific experiments can be used for developing real theories and models.

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into how business decisions are and / or ought to be made to inform design of autonomous cognitive agents and business decision support systems (Fox ;2010)?

Research Gaps and Open Questions Identified

Research gaps identified in this review are;

- **How does manager decide in a state of vacillation?**
- **How does manager decide in a state of Risk and Probability?**
- **How does manager decide in VUCA (Uncertainty, Vulnerability, Complexity plus Ambiguity)?**

There is a need to, as per gaps in research identified,

- Demonstrate distinctiveness of components by obtaining convergent and discriminant validity measures.
- Model neuromanagement decision making by using tools from neuro - management and cognitive neuroscience.
- Incorporate neuromanagement science and psychology of management modelling approach,
- Identify evidences for multiple systems involved in business decision-making.
- Clarify how neural circuits realize 'mental simulation' in managerial decision-making
- Offer a model about relationship between rationality, emotions and underlying neuromanagement underpinnings involved in business decision - making.
- Gain insight into how brain computes models for business decision-making
- Elucidate principles and business decision - making mechanism in brain interaction between variables of neuromanagement - management business decision processes.
- Understand neural processes underlying how managers craft business decisions and business decisions, understand mechanisms of business decision - making and integrating interdisciplinary research towards contributing to neuromanagement decision.

Conclusion

Real-world problems are often complicated. Psychological scientists have been interested in how people make business decisions for several decades, but philosophers and researchers have been studying business decision for centuries. Highlighting areas of overlap between cognitive modeling and multi-attribute judgment will stimu-

late further cross-fertilization and inspire research examining the boundary conditions of various models. Managerial choice neuroscience offers a novel approach to the study of both individual and interactive managerial choice by combining the methods of emotional experiments, functional neuroimaging, and formal management models. Use of this methodology has the potential to advance our knowledge of existing theoretical accounts of how people make managerial choices and judgments by informing and constraining these models based on the underlying neurobiology. Examining sophisticated high-level behaviour at a neural level, such as deciding on how much risk to take with an investment or deciding on a strategy when playing a competitive game with an opponent, can provide important clues as to the fundamental mechanisms by which managerial choice-making operates. Despite substantial advances, the question of how we make managerial choices and judgments continues to pose important challenges for scientific research. Historically, different disciplines have approached this problem using different techniques and assumptions, with few unifying efforts made. However, the field of neuromanagement has recently emerged as an inter-disciplinary effort to bridge this gap. Research in neuroscience and psychology has begun to investigate neural bases of managerial choice predictability and value, central parameters in the management theory of expected utility. Management, in turn, is being increasingly influenced by a multiple-systems approach to managerial choice-making, a perspective strongly rooted in psychology and neuroscience. The integration of these disparate theoretical approaches and methodologies offers exciting potential for the construction of more accurate models of managerial choice-making (Satpathy, Sturman, et. al. 2015).

High-quality decision making has never been more important or more difficult. Senior business leaders are striving to position their organisations to thrive in the short, medium and long term, but they are having to do so in an operating environment that is volatile and uncertain. Over the past half century, researchers have responded to the challenges raised to neoclassicism either by bounding the reach of economic theory or by turning to descriptive approaches. One recent trend in economic thought may reconcile this tension between prescriptive and descriptive approaches. There is some hope that it may yield an economic theory that is both highly constrained and parsimonious while still offering significant predictive power under a wide range of environmental conditions. That trend is the growing interest amongst both researchers and neuroscientists in the physical mechanisms by which human neuroeconomic

managerial economic business decisions are made within the human brain.

There is reason to believe, some of these neuroeconomic scholars argue, that the basic outlines of the human neuroeconomic managerial economic business decision architecture are already known and that studies of this architecture have already revealed some of the actual computations that the brain performs when making neuroeconomic managerial economic business decisions. If this is true, then a combination of economic and neuroscientific approaches may succeed in providing a methodology for reconciling prescriptive and descriptive economics by producing a highly predictive and parsimonious model based on the actual economic computations performed by the human brain. While both of these strategies have been enormously fruitful, neither has provided a clear programmatic approach that aspires to a complete understanding of human neuroeconomic managerial economic business decision as did neoclassicism. The history of economics has been marked by an iterative tension between prescriptive and descriptive advances (Satpathy and Pati; 2015).

Respecting growing complexity of organisational life, in past decades, landscape of work has turned complex. Technological advances, widespread globalisation, and increased diversity have resulted in competitive organisational environment that is fast and dynamic. Work presents with grander experiments required to operate in considerably volatile, uncertain and complex realm. Onus is to create inventive ways of developing capabilities to 'engage with multifaceted, vibrant, disordered and idiosyncratic, interactional environs of contemporary organisation. Organisational psychology, study of scholarship to workstation issues, is functional to explore issues of critical relevance. Issue is; where have we been with organisational neuroscience? Neuroscience paradigm has adopted neuroscientific outlines, approaches and apparatuses to comprehend organisational behaviours and phenomenon. Although incredulous issues have been raised, field of organisational neuroscience is aware of limitations and advocates for theoretical plus methodological contributions. Organisations are in a sprint to improve bottom line. Neuroscience provides 'seminal lens' to build core, justifiable attentiveness and competence and push boundaries to contribute meaningful insights. How can we leverage our brain in business? Organisational neuroscience integrates organisational behaviour with neuro - scholarship that involve neural substrates as they relate to social - cognitive phenomena in organisational contexts. Reasonably different, approach is rooted in 'social neuroscience', which entails a multilevel approach involv-

ing, factors; internal and external to individual contexts. Organisational behaviour in a neuroscientific perspective, employ direct measures of brain activity using functional magnetic resonance imaging (fMRI), electroencephalography (EEG) and magneto encephalography (MEG) that promise new queries, deciding debates and amalgamating theories. Is it so organisational neuro - business decision dynamics (Satpathy, et.al. 2017)!

It is obvious that classical, emotional and quantitative approaches have all made valuable contributions to the theory and practice of management. Contemporary management seeks to integrate these approaches in ways that suit the particular organization at a particular time. A thorough understanding of management requires an appreciation of all three perspectives Systems theory and contingency theory take this integration approach. The systems approach describes the organization as a system that transforms inputs (material, human, financial and information resources) into outputs (e.g. products/services, profits/losses, employee behaviour and information) by use of managerial and technological processes. The overall system can be broken into sub-systems, such as production and finance. The objectives are effective and efficient operation of each of the sub-systems, to maximize the synergy between the sub-systems and to avoid entropy (the natural tendency for systems to decline over time). The contingency approach essentially argues that the traditional perspectives on management are too narrow in defining how to manage organizations. It suggests that the best managerial approach to each particular situation is dependent on a large number of elements and therefore managers should seek the approach that best suits the specific situation they are facing. The text suggests that the broader approaches to management taken by the systems and contingency approach have most relevance to the manager of 21st Century who faces complex and rapidly changing environments.

How can we leverage our brain in business? How can we capitalise / invest on the brain? How can we make the best business decision? How can we find the productivity 'hot buttons' in the brain? How can we encourage creative and ethical brain? What is the nature of explanation in Manager / employee neuro - Management? What information about the past is relevant to Manager / employee neuro - business decision? What past experiences cannot be 'unlearned' in view of subsequent developments? How does experience influence our business decisions? What kinds of experiences would produce better business decisions and better adaptation? How does experience transfer to new situations? What learning processes take place

during sampling and repeated consequential business decisions? How do these processes alter when business decisions are interrelated over time? When feedbacks are delayed? When business decisions are time - dependent? How do we address consequential and sampling business decisions when the 'organisational environment' is dynamic? When it involves other individuals? What learning processes take place during sampling and repeated consequential business decisions? How do these processes alter when business decisions are interrelated over time? When feedbacks are delayed? When business decisions are time-dependent? How do we address consequential and sampling business decisions when 'environment' is dynamic? When it involves other individuals? How does manager or employees make business decisions in dynamic stock management tasks? How does manager or employees perceive accumulation over time? Why does employer or employees perform so poorly at control tasks? How can judgments of accumulation be improved? What are the effects of feedback complexity and feedback delays? How are theories represented in computational models? How can we validate and test theories/hypotheses with computational models? What is the value of using video games and simulations in emotional business decision research? How can we best present, measure, and analyse data on human learning? How does Manager or employees make inferences from numbers? How do Manager or employees process logic representations of data relationships? Is the representation of the past in any sense 'rational'? Are affective as well as cognitive processes involved? Can the Manager / employee neuro - present rewrite the Manager / employee neuro - past? What are the implications of memory-dependence for modeling and policy-making? Is there place for emergence in Manager / employee neuro - al explanations; in particular, how does one take into explanation downward causality? Is psychology indispensable for understanding of Manager / employee neuro - al phenomena? What can and cannot one expect of mathematical modeling in Manager / employee neuro - Management? Does Manager / employee neuro - Management have an ontologically sound domain? How dissimilar are biological systems and Manager / employee neuro - al ones? Is an analysis of various notions of rationality (including bounded rationality) still important, and if so, why? What is bounded rationality? A complete answer to this question cannot be given at the present state of the art. However, empirical findings put limits to the concept and indicate in which direction further inquiry should go. What has philosophy of Manager / employee neuro - Management to say about the present crisis? What has philosophy to offer the methodology of emotional Manager / employee

neuro - Management and 'neuro manager / employee Management?

The path to better understanding the economy requires treating the economy as the complex system that it really is. We need more realistic emotional models, but even more important, we need to capture the most important components of the economy and their most important interactions, and make realistic models of institutions. The complex systems approach is intermediate between traditional economic theory and econometrics. Traditional economic theory is top-down, modeling decision making from first principles, and then testing against data later. By 'first principles' I mean the requirement that theories have 'economic content', i.e. that they derive behaviours from preferences. Econometrics, in contrast, takes a bottom up, data-driven, but fundamentally ad hoc approach. The complex systems approach sits in the middle, taking a bottom up data-driven approach that differs from traditional econometrics by explicitly representing agents and institutions and modeling their interactions, without the requirement that everything be derived from fundamental principles. It has the potential to free emotionalism from the straightjacket of equilibrium modeling, and to bring the computer revolution fully into economics. This path will at times involve abandoning economic content in favor of economic realism (Farmer; 2012).

There is growing interest in exploring potential links between human biology and management in explaining human behaviour. The study of business decision require extensive empirical study and setting for basic research on how ill structured problems are, and can be, solved. Neuromanagement is a brave new world of research that offers a solution through additional set of data obtained via a series of measurements of brain activity at time of business decisions. This provides a conceptual and philosophical framework for understanding and conducting neuromanagement research at intersection of neuroscience, management and psychology. It describes a standard model for business decision process that links and spans neurobiological, psychological and management levels of analysis. Attempt has been to apply neuroscience to neuro-management and tie both fields to biological constraints in how we judge relative value and make business decisions. Measurement of brain activity provides information about underlying mechanisms during business decision processes (Satpathy and Gankar; 2016).
